THE MENTAL AND PHYSICAL LIFE OF SCHOOL CHILDREN

PETER SANDIFORD

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THE
MENTAL AND PHYSICAL LIFE OF SCHOOL CHILDREN

BY

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WITH ILLUSTRATIONS

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TO

MY FORMER TEACHER

EDWARD L. THORNDIKE

THIS BOOK IS GRATEFULLY

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PREFACE

My object in writing this book has been to present a comprehensive account of Child Nature for the use of students in Training Colleges for Teachers. The experience I have gained during the past seven years with students in England and America is embodied in this work.

The book is intended to serve as a text-book, *i.e.* it aims at giving, in as brief a space as possible, a large number of facts which may be utilised in class discussion. Some parts of the work may appear too difficult for the young student, but the method of treatment seems justified by the great advance which scientific investigation has made in this branch of Education. Some of the topics discussed are of a controversial nature, and where this is the case, I have endeavoured to present both sides of the question in a frank and dispassionate manner.

It is an axiom of Science that if two hypotheses explain certain facts or phenomena equally well, the simpler should be chosen. Believing that the mechanistic conception offers the simplest explanation of mind, I have assumed throughout this work (though not without considerable misgivings in places) that all mental action has a physical basis. This has led me to give a more detailed treatment of the structure and functions of the nervous system than is usual in books of this nature. The technical terms, which are of necessity introduced, will probably be found confusing at first, but experience shows that the initial bewilderment soon gives way to clearer knowledge.

Mind tends to express itself in action; a study of the mind in action (Dynamic or Functional Psychology) occupies the major part of these pages; Descriptive Psychology is relegated to a very secondary position.

In the development of child nature, change and growth are the outstanding features. These aspects I have endeavoured to emphasise throughout the whole book.

The arrangement of topics discussed in the various chapters calls for a note of explanation. The book is divided into three main parts. In the first, the physical life of the child is discussed, because facts falling within this category are usually comprehended more easily by the young student. The second part deals with the physiological basis of mental life and serves as an introduction to the more strictly psychological treatment which follows. In the third part, the mental life is described in some detail. Illustrations from other fields are freely used and the results of experimental investigations are included wherever possible. The later sections of the book are applications of the findings of previous ones.

I have opened with a discussion of the problem of heredity and environment from the standpoint of the educator. The importance of this topic cannot be over-emphasised, for the conclusions which the people of a nation reach with regard to it consciously or unconsciously affect the whole of its educational organisation and procedure. Chapter III. on "The Statistical Treatment of Educational Measurements" is for reference purposes only, the statistical terms used in other parts of the book being there explained.

Sensation logically belongs to the section on Descriptive Psychology. It is discussed in the chapter on sense organs to preserve a simplicity of arrangement. No difficulty should be found with the order of the other chapters. I have made no attempt to make the reference lists exhaustive, but trust nevertheless that they will be helpful for further study.

I have received help from every previous writer on the subject whose works I have read, but I should like to acknowledge my especial indebtedness to the writings of Dr. E. L. Thorndike. The inscription of the book to this highly original thinker and investigator is but a poor recognition of the help and stimulus I have received from him.

The manuscript has been read by Dr. I. L. Kandel and my wife, and in part by Mr. T. H. Pear; the proofs have been corrected by Mr. S. E. Maltby and Mr. A. E. Codd. I wish to express my thanks to them all for their generous help and valuable criticisms. P. S.

MANCHESTER, 1913.

PREFACE TO SECOND EDITION.

IN this edition a few minor corrections have been made.

P. S.

TORONTO, 1915.

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SECTION I.

THE PHYSICAL LIFE OF THE CHILD.

CHAPTER I.

HEREDITY AND ENVIRONMENT.

The Correlative Nature of Heredity and Environment. A human being at any time of his life is the product of two influences—heredity and environment. The zygote (fertilised ovum) from which he grew and developed possessed at the moment of its formation the finite and fixed hereditary possibilities which might or might not be realised during subsequent existence; his environment, on the other hand, has never been identically the same for two consecutive seconds, and never will be. Yet it must not be thought that hereditary influences ceased at the moment of fertilisation and that chance environments alone have made the individual what he is to-day; rather must we think of environment as the field in which hereditary traits and capacities are developed, of heredity and environment as strict correlatives, and as inseparable factors in organic growth and development.

Definition of Heredity. The term heredity has been variously and often loosely defined. By some writers it is looked upon as a force moulding the offspring in the likeness of the parent, by others as the antithesis of variation, *i.e.* heredity is the resemblance, and variation the dissimilarity between progenitors and descendants. Perhaps it may be best defined as the complete potentialities of an organism at the moment of impregnation, but for practical purposes we are forced to accept the definition that heredity is the complete congenital equipment of the individual. Hence, if we study a man's native endowment, we study his heredity. The study usually takes the form of comparing an individual's traits, both physical and mental, with the traits of some of his ancestors, immediate or more remote.

Specialisation of Heredity. The primary fact about heredity is that "like tends to beget like," that there is an inherent tendency of the offspring to resemble its progenitors both in form and function. A closer examination reveals the fact that the likeness is only superficial, for there are numberless small differences or variations. This leads us to suppose that heredity is highly complex and specialised, and that there may be relatively large variations of minute parts without affecting the structure in gross. We may look upon an individual as a bundle of thousands of mental and physical traits. And no two bundles are alike, not even in those cases of extraordinary likeness sometimes found in twins. Some children are born to be tall, others to be short; some to be intellectual, others to be stupid, and so on. Given sets of traits are often found in correlation, yet it is helpful to look upon each trait as separate and independent. If we represented the heredity of individuals by diagrams, we should get something like the following:

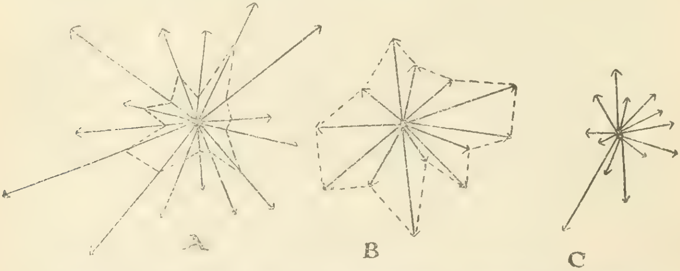


FIG. 1. The dotted "circle" at B represents a completely developed individual. Such a person, of course, is purely imaginary. The "circle" at A, for a person say of 40 years of age, is far more true to facts.

In the diagram a capacity or trait is represented by an arrow. (There ought to be thousands of arrows but the diagram will not permit of them being drawn.) Each trait in itself is a compound of many simpler traits, *e.g.* a man's weight is a compound of the weight of bones, muscles, fat, etc., or is a compound of the weight of his head, trunk, neck and limbs. These simpler traits are analysable into something still more elementary and so on *ad infinitum*. The length of the arrow represents the amount of endowment in any given trait. Thus A, on the whole, is exceedingly well endowed ; B moderately so ; while C is extremely deficient. If mental traits alone are considered, A represents the type known as genius, B the average person, and C the mentally defective. But there is no sharp line of demarcation between the types ; all tests and measurements show that there is a continuous scale of variations from the dullest idiot to the brightest genius. A man may be quite dull along some lines and brilliant along others ; thus a genius at mathematics or at music may be quite hopeless where leadership of men is concerned. Generally speaking, however, nature does not work on a plan of compensation : she seems to say that " unto every one that hath shall be given, and he shall have abundance," so that we usually find a clever man gifted in many directions, though never in all. (See Fig. 1.)

Heredity as a limiting factor. Heredity not only determines what traits a man shall possess, but also limits their possible development. This fact is often overlooked in discussions about the development of mental traits, for we are apt to suppose, because we never reach the limit of nature's mental and moral gifts, that there is no limit to them. Yet all teachers know that different individuals have different mental equipments just as they have different physical equipments. It is evident to all that, no matter what stimulus is applied, a child cannot be made to grow to 20 ft. in height ; yet a similar situation with respect to mathematics, music or piety is seldom realised. No one observing a mentally or morally defective child can deny the existence of his limitations. If such limitations of nature are not accepted, we must hold to the view that, given sufficient time, all people can be taught all knowledge and can develop all virtues.

Environment. Environment may be looked upon as the sum of the stimuli tending to develop the inherent traits or capacities of individuals. Environment may also destroy traits and capacities that have already been developed. A blow on the head may destroy the mental capacity of the greatest genius : a shot in a war may reduce a man's stature by the length of his legs. Environmental stimuli cannot develop traits which are not potentially present. A person who is stone deaf must for ever be insensible to the charms of grand opera; a boy with defective motor control can never make a skilled craftsman; while all of us are uninfluenced by the waves of wireless telegraphy because no recording apparatus for such has yet been evolved in human beings. A musician, such as Beethoven, if born in the depths of the African forests or in the wilds of Patagonia could never produce beautiful sonatas, although he might, perchance, become the best tom-tom beater of his tribe. In just the same way a child born in slumdom and poverty might have valuable powers atrophied or destroyed. It is not given to educators to create powers in individuals but, by supplying suitable environmental stimuli, they can prevent their waste or deterioration. Education, in its widest sense, is thus synonymous with environment, although in the narrower sense of schooling it is restricted to the specialised environment artificially created by adults for the development of the innate powers of the young. Since the wider environment cannot always be relied on to stimulate those powers which we, as adults, consider the essential attributes of human beings, we create and direct stimuli in school so that they literally bombard the individuals undergoing treatment. It would be a long time indeed before a child, if he ran wild on the streets, would learn that $9 \times 7 = 63$ or that William the Conqueror landed in 1066, yet such facts as these are taught with relative ease in the school.

This view of heredity and environment will explain some of the fundamental defects in our current conceptions of education. The fact that a teacher or inspector demands of each and every member of a class four sums right, a dictation or a composition without a single spelling mistake, writing that approaches a copperplate standard, and drawings of equal degrees of merit can only be explained on the assumption that the idea of different hereditary endowments of scholars has either not been grasped or has not been put into practice. Why should all children be put through exactly the same mill? Why should we expect them to develop at equal rates when experience shows that at the end of a course, in spite of all our wisdom (or stupidity) children differ far more than they did at the beginning?

Babies are far more alike than are children of thirteen or selected students of twenty. The same fundamental error was at the basis of the monitorial and the pupil-teacher systems in England, as well as of that great educational backsliding known as the system of "payment by results."

Variation. It has been pointed out previously that although offspring tend to resemble their progenitors, and that somewhat closely, differences or variations also occur. In biology a variation is defined as a filial departure from the parental type which is founded on a germinal change. The important part of the definition is that which insists on the germinal change. An accident which destroyed or injured part of an individual, *e.g.*, the amputation of a finger or the scalding of the face, would not be looked upon as the cause of a variation, because the scars or mutilations are not inherent and would not be reproduced in the succeeding generation. If, however, by the stimulus of food alone, and quite apart from the influence of use or injury, a person grew an extra (sixth) finger, this departure from the normal would be a true variation and consequently would tend to reappear in subsequent generations. The higher the animal and the more varied the environment in which it has to survive, the greater is the number of its variations. The power to vary is probably a "survival factor." In the case of lower animals living in a uniform and constant environment such as is furnished by a large expanse of water, there would seem to be no variation. The two daughter amoebae formed by "fission" of the unicellular parent are almost identically alike. Non-varying organisms demand a non-varying environment: an unfavourable change in the environment would annihilate the species. Such a situation, owing to variations, is practically impossible in the higher animals. A change in the environment, while unfavourable to some, would certainly favour others, and these would survive to impress their distinctive characteristics upon succeeding generations.

The mechanism of variation lies in the germs. The separate germs may be looked upon as different combinations of possible characters: should one germ be the cause of fertilisation one set of characters will appear in the organism: if another germ a correspondingly different set will appear. The variation in germs will explain why tall lean parents may have a short fat child, red-haired parents a black-haired child, and stupid parents a brilliant child. In general, however, variations obey two laws: (1) The law of distribution in a form resembling that of mere chance; (2) The law of regression towards the normal of the species or race.

(1) The law of chance may best be illustrated by an example. Suppose that all the men (10,000) of a given town were arranged in a long row beginning with the shortest and ending with the tallest. We should find that a line joining the tops of the heads would rise sharply at first, then remain almost horizontal for a considerable distance, and finally take another sharp turn near the end. The reason for this is obvious; there are but few very tall or very short men in a given community, the majority are of "average" height. If we represented each man by a line we should get a figure somewhat like the following:

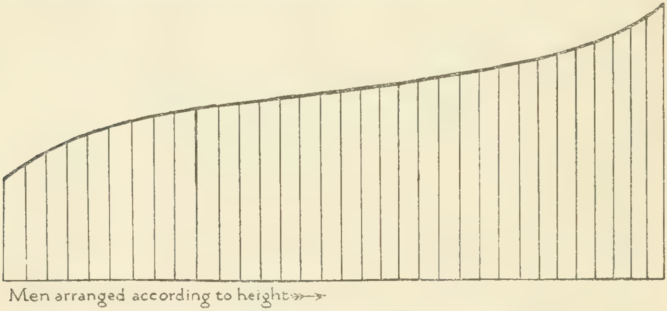


FIG. 2. Each vertical line represents a man. Only a small fraction of the 10,000 men is represented. The curve joining the tops of the lines is known as an ogive.

The peculiarly shaped curve obtained by drawing a smooth line through the tops of the perpendiculars is known as an ogive. A more usual way of representing such facts graphically is shown by Fig. 3.

The curve is obtained by plotting out the numbers of men whose heights fall between the various consecutive inches. It is known in statistics as a Normal Distribution Curve; a Normal Surface of Frequency; a Curve of Chance; or a Gaussian Curve. Such a curve could be obtained experimentally by plotting, in similar manner, the numbers of "heads" obtained when thirty coins are tossed a very large number of times, say 10,000. Fifteen heads would turn up most frequently, none and thirty extremely rarely, while the bulk of the results would cluster round the average.

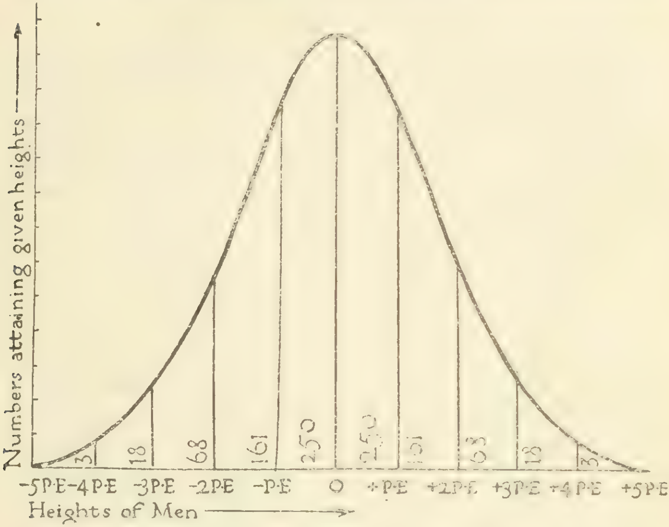


FIG. 3. A Normal Distribution Curve or a Normal Surface of Frequency. The theoretical distribution of 1000 persons is shown.

That the statures of adult men approximate this normal distribution curve is shown by Table 1 and its graphical representation Fig. 4.

Many of the measurements of variable traits, both physical and mental, approximate to this type of curve if a sufficient number of cases be taken. Complex mental abilities, as for example, general intellectual capacity, are, so far as is known, distributed in like manner.

(2) The second law of variation is more difficult to understand and explain. It would seem as if nature abhorred extremes or large variations of any kind; as if the average or normal were to be preserved at all costs. Keeping to our illustration of stature we find that tall parents have taller offspring than the average of the whole population, yet shorter than they themselves are; conversely, short parents are found to have shorter offspring than the average

of the population, yet taller than their own average. In an actual measurement, fathers seventy-two inches in height had sons of average stature 70·8 inches, while fathers of sixty-six inches had sons whose average height was 68·3 inches. The coefficient of correlation (see p. 55) for height between brother and brother will thus be greater than that between father and son. Pearson[1] found the former to be ·5 and the latter ·3. This law of regression

TABLE 1.

Showing the Stature of 8,585 Adult Males (age from 23 to 50) of the Population of the United Kingdom, arranged according to Place of Birth. *Final Report of Anthropometric Committee to the British Association*, 1883, p. 256.

Height without Shoes.		**Number of Men within said limits of Height. Place of Birth.**				Total.
Inches.	Metres.	England.	Scotland.	Wales.	Ireland.	
57–	1·448	1	..	1	..	2
58–	1·474	3	1	..	..	4
59–	1·499	12	..	1	1	14
60–	1·525	39	2	..	..	41
61–	1·550	70	2	9	2	83
62–	1·575	128	9	30	2	169
63–	1·601	320	19	48	7	394
64–	1·625	524	47	83	15	669
65–	1·653	740	109	108	33	990
66–	1·677	881	139	145	58	1223
67–	1·702	918	210	128	73	1329
68–	1·728	886	210	72	62	1230
69–	1·754	753	218	52	40	1063
70–	1·779	473	115	33	25	646
71–	1·804	254	102	21	15	392
72–	1·830	117	69	6	10	202
73–	1·855	48	26	2	3	79
74–	1·881	16	15	1	..	32
75–	1·906	9	6	1	..	16
76–	1·931	1	4	..	..	5
77–	1·957	1	1	..	..	2
Total,		6194	1304	741	346	8585

---

[1] *Biometrica*; Vols. III. and V.

towards the normal seems to be quite general for all the mental and physical traits of organisms; it holds for intellect as well as for length of legs and explains why races of giants, physical or intellectual, cannot be produced.

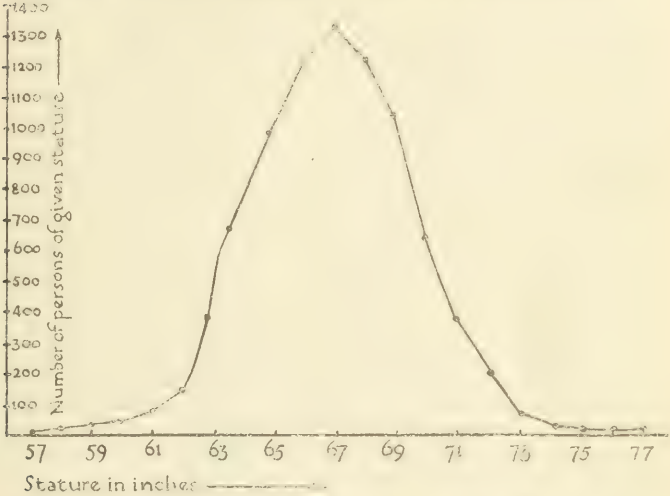


FIG. 1. Distribution curve for the stature of 8,585 adult males in the United Kingdom.

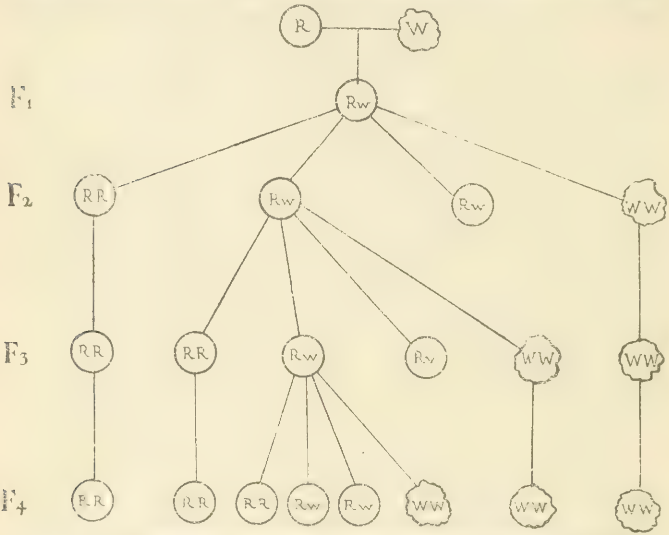
Variation as the basis of Evolution. Variation in the organism makes evolution possible. By organic evolution is meant an adaptive change that is undergone by a race. Animals and plants were not always as we now know them: they have gradually changed from some simpler form in response to a changing environment. This principle is the greatest generalisation of the present scientific era, and it is to Charles Darwin that we owe its clear enunciation. Man, who occupies the summit of the tree of evolution, is no exception to the rule. Comparative anatomy shows him to be a blood relation of the monkey and a more distant relation of other mammalia, reptiles, amphibia and fishes. Embryological evidence shows that in his development he passes through many simpler animal forms, vestiges of which remain after birth. Palaeontology—the study of fossil remains—while giving evidence of a more fragmentary nature, also supports the principle, all the records found being favourable to this theory.

Variation in itself is unable to effect an evolution of species. There must be in addition, as Darwin pointed out in his *Origin of Species*, a struggle for existence and the elimination of the unfit. Organic evolution has thus proceeded through the natural selection of suitable variants. A few brief examples must suffice. The giraffe has descended from a comparatively short-necked animal that fed on the leaves of the lower branches of trees. We can imagine a descendant of a primitive giraffe having a variation in the direction of a longer neck. He would thus be enabled to reach more food, grow bigger and stronger, and defeat his companions in love and war. Since the change was a germinal one, his descendants would tend to inherit the variation and those doing so would obtain additional advantages in the struggle for existence. This process would go on through the ages and eventually the long neck of the giraffe would be evolved. The development of the neck would cease as soon as the advantages and disadvantages of its possession balanced each other as survival factors. In exactly the same manner the present day trunk of the elephant has been evolved from the "mere-smear" nose of his prehistoric ancestor. With man there is much greater difficulty in tracing the stages of his evolution. Certain it is that at some period in his history the variation of his brain in size and complexity became effective as a survival factor, for man found himself able to gain by cunning and strategy what he had formerly gained by force. In evolution a short view shows little change: observation over a long period of time gives marked indications of the process. Man is estimated to have been on the earth at least two hundred and fifty thousand years: even this period is none too long for all the changes to have taken place.

Mendelism. The foregoing explanation makes evolution dependent upon the successful influence of small variations. It matters not whether the mechanism is the selection of favourable chance variations, or if ortho-genesis—the tendency to vary in a positive rather than a negative direction so far as useful functions are concerned—plays its part. There are, however, many difficulties in the way of this explanation. Why should a small variation possess such a great survival value ? The whole of the difficulties are not explained away even by the hypothesis of Lloyd Morgan, which states that slight variations which have in themselves small survival value, may, if possessed by an organism which has great power of accommodation or learning, be developed and so attain a value as a survival factor. The theory of heterogenesis, which supposes that large variations occur and so produce entirely new and stable varieties (pure lines), has not yet been proved, though evidence in its favour is on the increase. It finds great support from the biologists of the Mendelian school, whose experiments seem to indicate an evolution by a series of jerks or jumps rather than by a steady, progressive and almost imperceptible change. They postulate the inheritance of unit characters which are stable and constant, and the production of new varieties by different combinations of these hereditary elements.

The founder of the Mendelian School was Johann Gregor Mendel, a monk of Brünn in Bohemia, who performed a classical series of experiments with the edible pea in the early sixties. This work was forgotten, or at least not recognised at its true worth, until it was repeated in 1900. The following may be taken as a type of Mendelian experiment : If a pea (W) which has a wrinkled skin when dry is sown and crossed with a pea (R) which remains round when dry (owing to the nature of the starch grain), the resultant peas (F_1) of the first filial generation are all round, no matter which way the fertilisation is performed—round to wrinkled, or wrinkled to round. If now the F_1 peas are sown and self-fertilised or crossed indiscriminately between themselves, the resultant crop F_2 is composed of twenty-five per cent. of wrinkled peas and seventy-five per cent. of round peas. But the roundness is now of two kinds. Twenty-five per cent. when self-fertilised or crossed with the original round pea breed true with respect to roundness through practically an indefinite number of generations. The other fifty per cent. are not pure " rounds," for on self-fertilisation or on crossing with F_1 there is a repetition of the behaviour of F_1 when it was self-fertilised, *i.e.* twenty-five per cent. pure " rounds," twenty-five per cent. pure " wrinkled " and fifty per cent. of the mixed variety are obtained. These phenomena may be obtained so long as the experiment is continued. Fig. 5 gives the result in diagrammatic form

The Mendelian explanation is very simple. There exist in the germs of the peas two varieties of characters—in one wrinkledness, in the other roundness. But roundness predominates in the crossings, hence this character is said to be *dominant*, while wrinkledness is said to be *recessive*. Each germ, so far as peas are concerned, may be said to have two unit characters or *determiners*. The crossings which produce the F_1 generation can only produce one type of offspring, the (Rw) type. Self-fertilisation of the F_1 generation can produce three types, as will be seen from Fig. 6 (II.), namely (RR), (Rw), and (WW); and the (Rw) type will be twice as numerous as either of the other two, providing the fertilisation is according to the laws of chance. Other dominant characters found in peas are long stems over short stems, yellow cotyledons over green cotyledons, purple flowers over white flowers, inflated ripe pods over constricted ripe pods, green unripe pods over yellow unripe pods, and axial flowers over terminal flowers. If, however, a variety has one character dominant, say tallness, it does



5. Diagrammatic representation of a typical Mendelian experiment with round and wrinkled peas. "Roundness" is dominant and "wrinkledness" is recessive.

not follow that its other qualities, *e.g.* colour of flowers, etc., are also dominant. Hence by judicious crossings many different varieties may be produced.

Similar experiments have been performed on animals such as mice, guinea-pigs, fowls, pigeons, canaries, sheep, etc., and the results show that while unit characters, for the most part, are inherited as wholes, the strict Mendelian dominance is not preserved; the Mendelian dominance seems to be a matter of degree only and not of kind. The number of determiners or unit characters seems to increase as the scale of evolution is ascended. In man, if Mendelian inheritance be followed, the number of unit characters must be very great. Still, certain features, such as eye-colour, hair colour, polydactylism, brachydactylism, haemophilia, chorea ("St Vitus' Dance"), some forms of colour-blindness, some forms of feeble-mindedness and night-blindness (the inability to see in a dull light), seem to follow Mendelian laws. Other traits such as skin colour, insanity and imbecility are much more doubtful and complicated. It is worthy of note, however, that the normal surface of frequency so often found by biometricians when measuring a given trait in a large number of individuals, is easily explained on the assumption that the number of unit characters is very great, and that chance alone determines fertilisation.

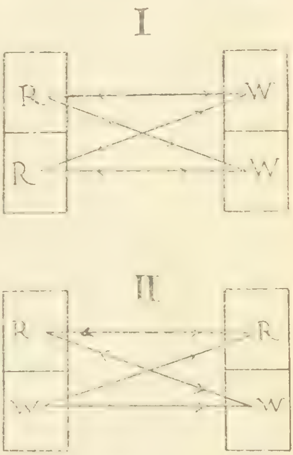


FIG. 6. Diagram to illustrate how the various percentages are obtained in Mendelian experiments.

Inheritance of Acquired Characters. Another question which vexes students of heredity and drives them into hostile camps is that of the inheritance or non-inheritance of acquired characters. It has been shown previously that environment can either develop or prevent the development of innate powers. It may also destroy them after development. The environmental stimuli may be classified under three heads—nutrition, use and injury. No character developed by nutrition or by use *plus* nutrition can possibly be an acquired character;[1] while characters obtained through injury are always acquired. The capacity for large development of muscles found in an athlete is innate; use and nutrition have simply developed them to the fullest possible extent. The loss of a finger or the distortion of the spine are acquired characters because nature did not from the beginning intend such loss or distortion. Hence the usual definition of an acquired character, as one that is not germinal but arises under the stimulus of use or injury, needs modification. In the first place, "use stimuli" can never develop anything unless nutriment is also present; secondly, they can never develop powers which are not already present. The real questions at issue are the following: (1) are characters acquired by injury in this generation, developed by nutrition alone in the next? (2) are characters abnormally developed by nutrition and use, developed by nutrition alone, or by nutrition and a smaller amount of use, in the succeeding generation?

The answer to the first question seems to be decidedly in the negative. Mutilations, even when practised for many generations, are never inherited. Sheep, horses and dogs have had their tails docked for generations, yet tailless breeds have not arisen; Chinese babies are born with feet of normal size in spite of foot-mutilation by generation after generation of Chinese women; and English girls do not inherit the eighteen-inch waist of foolish mothers. The experiments of Brown-Sequard on guinea-pigs seemed to prove that mutilations of the central nervous system were inherited, but repetition of his experiments have failed to confirm the results, and other equally plausible explanations are possible.

The second question is more difficult to answer because of the difficulty of isolating the various factors involved. For example, a man studies science or mathematics and his children also turn out scientists or mathematicians. The most obvious explanation is that exercise along these lines on the part of the parent has been beneficial. But other explanations are possible. It may be that both parent and child come of stock that has long devoted itself to scientific or musical pursuits. Absence of stimuli may have been the cause of its non-appearance in earlier generations. Again the trait may have been a variation which appeared for the first time in one of the parents, and being a germinal change it re-appeared in the offspring. And so with other characters like the large muscles of the athlete. The son of an athlete would never develop into a man as strong as his father if he led a sedentary life. Crucial experiments such as could be performed on quick-breeding animals like mice, rats and guinea pigs are needed, but they have not yet been performed.

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[1] This is a slight variation from the Lamarckian use of the term.

Weismann's Theory of the Germ-Plasm. This theory, put forward by Weismann in 1885, lends support to the preceding arguments. According to Weismann the germ-plasm is the originator of the individual, for only when a portion of the parent germ-plasm is separated off can the daughter organism arise. The germ-plasm is thus continuous, everlasting and immortal so long as the race survives. But this does not mean that the germ-plasm of man is the same as the primordial protoplasm which floated in the primitive ocean ; rather must we think of it as continuous in the same sense that a man is a continuation of the boy. Part of the germ-plasm may, in the subsequent development of the individual, change or " differentiate " to various forms of body-plasm, but body-plasm may never revert to the germ-plasm from which it was formed. The somatic (body) cells serve as a means of shelter and nutrition to the germ cells and it is the latter alone that are the bearers of heredity. The body cells cannot give living elements to the germ cells, for there is no mechanism by means of which such a transference may be effected. In other words, the theory of the germ-plasm implies the non-inheritance of acquired characters.

Acquired Characters and Education. If the contention that acquired characters are non-transmissible be true, it follows that Education, in the popular sense of the term, is for one generation only, *i.e.* an abnormal development of any capacity in the parent by excessive stimulation will not develop to an equal extent with less stimulation in the next generation. No amount of learning on the part of the parent will make the offspring less innately stupid : property may be " willed " to offspring and so make his struggle for life easier, but mental acquisitions can never be " willed "—they must be obtained by struggle and effort as they were by our parents before us.

How can such a statement be reconciled with the fact that the intellectual struggles of parents *do* help the children and in a very real way? The reconciliation is found in what has been termed "social heredity." Though the parent may not influence the germ-plasm of his offspring in any direct fashion, he can, by surrounding him with the desirable stimuli of culture—books, schools, travel and so forth—facilitate the development of his natural powers. Hence we see why it is that cultured people usually spring from cultured homes, that sons so often follow the professions of their fathers and that there is an apparent inheritance of acquired characters.

The whole tendency of modern civilisation is to extend the sphere of influence of social heredity. Education is now compulsory in all the leading countries of the world. Free art galleries, free libraries, cheap newspapers, and rapid transit place before the humblest and poorest persons the luxuries of the aristocrats of a previous generation. Never in the history of the world has a "lad of parts" found it so easy to rise in the social scale. The stimuli to development are well-nigh omnipresent. Hence we may expect the culture of the home to diminish in influence and the apparent inheritance of acquired characters to become less noticeable.

But this does not get over the main contention of this chapter—that like tends to beget like. Gifted persons acquiring culture with little effort will probably have children who acquire it about as easily; the struggles of parents of puny intellect, even though they ultimately command an honourable position in the world, will not ease the burden for their offspring. Hence the claim of the Eugenists that improvement of environment alone will not produce a higher and permanently better race receives great support.

The relative influence of Heredity and Environment. The position that has been maintained in the foregoing sections indicates that a discussion of this subject is somewhat beside the mark. It has been shown that both factors are necessary and must be taken into account. Either without the other is impotent. Yet many wars have been waged on the question. The issue is always in doubt because of the impossibility of isolating the factors. The influence of environment could be investigated in such an institution as an Orphan Asylum, for there the environment, so far as we are able to make it, is the same for all, while the child inmates have each a different hereditary equipment. The other side of the question—the influence of heredity—can best be studied in the case of twins, especially in those cases where each of the two members are reared in separate homes or localities.

Unfortunately there are no scientific researches of the former kind. We all know that "institution children" tend to resemble one another and to get the "institutional mannerisms," but it is debatable whether the resemblances are greater than are those between Eton or Rugby boys. Scientific researches into the question ought to be carried out; they would be difficult but not impossible.

Of the latter type of studies those of Galton[1] and Thorndike[2] are the best known.

Galton firmly believed that heredity was much the stronger factor. But since he relied on statements made by parents, his conclusions have not much scientific value. He states (p. 172), "The impression that all this leaves on the mind is one of some wonder whether nurture can do anything at all, beyond giving instruction and professional training. . . . There is no escape from the conclusion that nature prevails enormously over nurture when differences of nurture do not exceed what is commonly to be found among persons of the same rank of society and in the same country. My fear is that my evidence may seem to prove too much, and be discredited on that account, as it appears contrary to all experience that nurture should go for so little."

Thorndike's study is much more valuable from a scientific standpoint, for objective measurements only were made. The subjects were fifty pairs of twins chosen at random from the schools of New York City. The tests employed were 14 in number, 8 physical and 6 mental. The physical tests included measurement of height, width of head, circumference of head, cephalic index, *i.e.* the ratio of the breadth to length of head, length of forearm, etc. The mental tests were (1) "A" test—ability to mark A's in a page of mixed letters; (2) "a-t" and "r-e" tests—ability to mark words containing ***a*** and ***t*** or ***r*** and ***e***; (3) Misspelled word test—ability to detect mistakes in spelling; (4) Addition test—ability to add correctly; (5) Multiplication test—ability to multiply correctly; (6) Opposites test—ability to give the words meaning the opposite of the words in the list (*e.g.* up—down; inside—outside; good—bad, etc.).

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[1] F. Galton: "History of Twins," in *Inquiries into Human Faculty and its Development*; London, 1883. Reprinted in Dent's Everyman Series, pp. 155-173.

[2] E. L. Thorndike: *Measurement of Twins*; Columbia University Contributions to Philosophy and Psychology, Vol. III., No. 3, 1905.

The argument used was as follows: If the resemblances are due to original nature, then the resemblance of twins should be greater than that of siblings (any children of the same parents); the resemblance of twins from 9-11 years of age should be equal to that of twins from 12-14 years of age; and the resemblance between trained twins should be equal to that between untrained twins. If, on the other hand, environment is the more potent factor, then the resemblance of twins should be equal to the resemblance of siblings; the resemblance between twins of 9-11 years of age should be less than that between twins of 12-14; and the resemblances between trained twins should be greater than those between untrained ones. The results, as measured by the Pearson coefficient of correlation (r) (see Chap. III.), were all in favour of the former argument. In both the mental and physical tests the resemblances of twins were about twice as great as those of siblings, and the resemblances did not alter with age or training. For twins r was about ·78 and r for siblings, as measured by Pearson and others, is approximately ·50. Thorndike states in conclusion that "the mental likeness found in the cases of twins and the differences found in the case of non-fraternal pairs, when the individuals compared belong to the same age, locality and educational system, are due, to at least nine-tenths of their amount, to original nature."

Other investigators have approached the problem of the relative influences of heredity and environment by endeavouring to estimate the effects of the various factors which have moulded the members of certain well-defined groups of people. Perhaps the most interesting of these studies from an educational standpoint are those of de Candolle, Odin, Galton, Galton and Schuster, Woods and Cattell.[1]

De Candolle. The persons studied by de Candolle were the past and present associates and corresponding members of the Academy of Science, Paris (founded 1666), the corresponding members of the Royal Society, London (founded 1662), and the foreign members and correspondents of the Royal Academy, Berlin (founded 1700). In all, the members studied were 212 for Paris, 235 for London, and 195 for Berlin. He concludes that the following eighteen influences were favourable to the progress of the sciences and hence to the development of genius :

1. A considerable proportion of the people belonging to the rich and leisured classes relative to those who needs must work constantly in order to live, and especially those who work at unskilled manual labour.
2. A considerable number of intellectual men of easy circumstances who are willing to devote their lives to scientific pursuits.
3. An ancient culture of the spiritual sides of one's nature directed for several generations into right channels.
4. Immigration of intelligent families having a taste for intellectual work.
5. Existence of several contiguous families having favourable traditions towards science and to intellectual occupations of every kind.
6. A good system of education, especially secondary and higher education, organised independently of politics and religion.
7. Abundant material means in the shape of libraries, laboratories, observatories, and so forth, for the pursuit of science.
8. Public curiosity for truth, rather than fiction.
9. Freedom of opinion.
10. Public opinion favourable to science and to scientists.

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[1] Alphonse de Candolle : *Histoire des sciences et des savants depuis deux siècles* ; Geneva, 1873.

A. Odin : *Genèse des grands hommes, gens de lettres français modernes*; *Paris*, 1895. (Candolle's and Odin's works are summarised in Ward's *Applied Sociology*.)

F. Galton : *Hereditary Genius : An inquiry into its laws and consequences* ; London, 1869 and 1892.

Galton and Schuster : *Noteworthy Families* ; London, 1906.

F. A. Woods : *Mental and Moral Heredity in Royalty* ; New York, 1906.

J M'Keen Cattell : "*A Statistical Study of American Men of Science*" ; Science, Vol. XVI., 1906, pp. 732 ff.

11. Liberty to exercise any profession.
12. Religion not placed upon an authoritative basis.
13. Clergy the friends of instruction.
14. Clergy not condemned to celibacy.
15. Habitual employment of one of the three principal languages—English, French, German—with as full a knowledge of non-native tongues as possible.
16. Small independent countries or a union of same.
17. Situated in temperate zone.
18. Proximity of civilised countries.

Switzerland was found at the head of countries producing scientific genius and de Candolle explains this by saying that she had a greater number of favourable conditions than any other country.

De Candolle is thus an "environmentalist"; nearly all of his eighteen factors are environmental.

Odin. Investigating the conditions which seemed to favour the development of literary talent, Odin found that urban life tended to produce and foster literary genius. The greater proportion of the 5620 notable French authors whom he studied was produced by Geneva, Paris, Marseilles, Dijon, Avignon, Lyons, Orleans, Metz and their immediate surroundings, and his conclusions again favour environment as against heredity. The criticism that Thorndike levelled at Cattell's results (*infra*) is valid here, namely, that the towns tend to attract the able and so would seem to produce more genius; that at bottom, the real cause of the supremacy is heredity.

Galton. Galton's *Hereditary Genius* is important because it embodies one of the first investigations of this nature. The faults in it are numerous, but may, for the most part, be excused on the grounds that the author was breaking new soil in a difficult subject. He studied the family relationship existing between a large body of fairly eminent men—Judges of England from 1660-1868, the statesmen of the time of George III., the premiers for one hundred years prior to 1868, commanders, literary and scientific men, poets, painters, musicians, divines, modern scholars, oarsmen and wrestlers. His method was to inquire whether these men had a much greater number of eminent relations than the generality of the population or that statistical estimates would accord them. As a result of his investigations he concluded that hereditary influences were more powerful than environmental ones.

For example, "the 977 men examined had relatives of the same degree of eminence to the following extent: fathers 89, brothers 114, sons 129, all three together 332; grandfathers 52, grandsons 37, uncles 53, nephews 61, all four together 203. The probable numbers of relatives of that degree of eminence for 977 average men are as follows: fathers, brothers and sons together, 1; grandfathers, grandsons, uncles and nephews all together, 3." [1]

The chief faults of the investigation are: (1) unfair selection: neglecting to take into consideration the whole of the members of a given group; (2) assuming that the true value of a man is given by contemporary public opinion; (3) neglecting to take into account the political nature of the office of judge; and (4) assuming that "genius will out"—a contention not yet proven. (There may be the swamping effect of poverty and other environmental factors.) Consequently his conclusion that the three factors found in practically all his cases—ability (intellectual), zeal (emotional) and capacity for hard work (will)—are hereditary is hardly justified by his evidence.

Galton and Schuster. The data of their study were the answers to a questionnaire sent to all the Fellows of the Royal Society, London, whose names appeared in its *Year Book* for 1904. Their results confirmed a previous research by Galton.[2] They show that able parents produce able children in a much larger proportion than the generality. They also think that genius seldom lies dormant, for they state that "the demand for exceptional ability, when combined with energy and good character, is so great that a lad who is gifted with them is hardly more likely to remain overlooked than a bird's nest in the playground of a school."

F. A. Woods. In *Mental and Moral Heredity in Royalty* Woods sets himself the task of tracing the influence of heredity through the whole of the members of a number of royal families. He thus got rid of the influence of selection but he introduced another possible error, namely that of personal bias, for he alone graded the subjects for intellect and morality each on a scale of ten. Ten marks for intellect represent genius, one mark represents feeble-mindedness or imbecility, while 5-6 represent mediocrity or the average. Similar ratings are given for morality. However, in fairness to him, it should be pointed out that his scores have never been questioned. The ratings were given after reading the easily available biographical material about each subject.

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[1] Thorndike: *Educational Psychology*; 1903 Edition, p. 53.

[2] F. Galton: *English Men of Science*; London, 1874.

So far as intellect is concerned he found that particular values existed in clusters. Thus high values centre around Frederick the Great of Prussia, Gustavus Adolphus of Sweden, and Isabella of Castile; low values cluster around George II. of England, Louis XVI. of France and in the royal lines of Spain and Russia where insanity and degeneracy persist through many generations; while medium values are found in the houses of Hanover, Denmark, Hapsburg in Austria, Saxony, Savoy and modern Portugal. He finds that hereditary traits and abilities, in spite of environmental influence, persist in families to a most remarkable degree.

Neither primogeniture nor periods of turmoil, stress and adversity have any appreciable effect on the production of ability.

Environment seems to have a greater effect on the morality of the royal persons studied. Morality also correlated highly with intellect.

In conclusion, he states (p. 286): "The upshot of it all is, that as regards intellectual life, environment is a totally inadequate explanation. If it explains certain characters in certain instances, it always fails to explain as many more; while heredity not only explains all (or at least 90 per cent.)[1] of the intellectual side of character in practically every instance, but does so best when questions of environment are left out of the discussion. Therefore, it would seem that we are forced to the conclusion that all these rough differences in intellectual activity which are susceptible of grading on a scale of ten are due to predetermined differences in the primary germ-cells."

J. M'Keen Cattell. This study is the best of its kind because errors of selection and of personal bias were rigorously excluded. A thousand American men of science were selected; "the number in each science was taken roughly proportional to the number of investigators in that science, the number being: Chemistry, 175; physics, 150; zoology, 150; botany, 100; geology, 100; mathematics,

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[1] See Thorndike: *Twins* (*supra*).

80; pathology, 60; astronomy, 50; psychology, 50; physiology, 40; anatomy, 25; anthropology, 20."

"The individuals were selected by asking ten leading representatives of each science to arrange the students of that science in order of merit. There were, for each science, slips made with the names and addresses of all those known to have carried on research work of any consequence. The ten positions assigned to each man were averaged, and the average deviations (see Chap. III.) of the judgments were calculated. This gave the most probable order of merit for the students in each science, together with the data for the probable error (see Chap. III.) of the position of each individual. The students of the different sciences were then combined in one list by interpolation, the probable errors being adjusted accordingly. The list contains 1,443 names, of whom the first thousand are the material used in this research."

"It should be distinctly noted that the figures give only what they profess to give, namely, the resultant opinion of ten competent judges. They show the reputation of the men among experts, but not necessarily their ability or performance. Constant errors, such as arise from a man's being better or less known than he deserves, are not eliminated. There is, however, no other criterion of a man's work than the estimation in which it is held by those most competent to judge."

From the data obtained, the place of birth of the scientist, university from which he obtained his first degree, institution in which he was working, etc., were worked out for each man. The results showed that "The main factors in producing scientific ability seem to be density of population, wealth, opportunity, institutions and social traditions and ideals. All these may be ultimately due to race, but, given the existing race, the scientific productivity of the nation can be increased in quantity, though not in quality, almost to the extent we wish to increase it." Yet in another place Cattell, after giving a table of institutions at which the men of science pursued their studies, is forced to admit that this part of the evidence at least "favours the theory that men of science are born such and are not dependent on the environment for the quality of their performance."

Thorndike's criticism (given previously) is that certain districts produce greater abundance of genius because the greater opportunities attract the abler men.

Galton's Law of Ancestral Heredity. The above studies, so far as they are concerned with heredity, take into account only immediate ancestry; the question of race or remote ancestry is not dealt with at all. Galton tried to evaluate the contributions of the various ancestors to the make-up of a given individual. He concluded that on the average half the heritage of an individual may be taken as derived[1] from the two parents, one quarter from the four grandparents, one eighth from the great grandparents, and so on in arithmetical progression. The series is thus $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}$, or for each individual, $\cdot 5^2, \cdot 5^4, \cdot 5^6, \ldots$ ancestor of nth place $(\cdot 5)^{2n}$.

Pearson, however, in his researches has shown that the parental contribution is greater than that assumed by Galton. His series runs ·6244, ·1988, ·0630.

Influence of Remote Ancestry or Race. Very few studies have been made on this important topic. Galton after one of his researches came to the conclusion that if the Greeks of the Golden Age were placed 14 on a scale of 14, modern Europeans would be represented by 12, and modern Africans by 10.

Thorndike[2] summarising an unpublished study by Mayo on the relative abilities of whites and negroes entering the High Schools of New York City, states: "whatever be the difference in the selection of the two groups, coloured beginners in high schools of New York City differ from whites in their careers there as follows:

(1) On the average they are eleven months older, only 36 per cent. of them being as young as the median (see Chap. III.) white.

(2) They continue in high school longer.

(3) In achievement in the different studies they are somewhat, but not very much, inferior. The general tendency is for only three-tenths of them to reach the median record for whites.

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[1] He really discusses the degree of resemblances found, which is not quite the same thing.

[2] *Educational Psychology*; 1910 Ed., p. 52 ff. It should be noted that the High School of America is superimposed upon the elementary school. Children first complete the elementary school and then pass on to the High School at an average age of fourteen years.

(4) The difference is greatest in the case of English, in which only 24 per cent. of the coloured pupils reach or exceed the median for whites."

The same small racial differences are shown to hold by Woodworth[1] in his excellent summary of researches into racial differences. But it must be remembered that small racial differences have profound social significance. A slight mental superiority makes a ruling and dominating race: a slight inferiority in ability may, and does, condemn a whole race to be "hewers of wood and drawers of water."

Conclusion. The problem of heredity and environment has been shown to be extremely complex. Present day schooling largely neglects the factor of nature (or heredity) and tries to develop all to an equal degree irrespective of endowment. A much more subtle analysis of the capacities of children is needed in schools in order to prevent the waste of much valuable time and effort.

References. Cattell: *A Statistical Study of Eminent Men*; Pop. Sci. Mo., 62. pp. 359-377. Cattell: *A Statistical Study of American Men of Science*; Science, XVI., 1906, pp. 732 ff. De Candolle: *Histoire des Sciences et des Savants depuis deux Siècles.* Doncaster: *Heredity in the Light of Recent Research.* Dugdale: *The Jukes.* Ellis: *A Study of British Genius.* Galton: *English Men of Science.* Galton: *Hereditary Genius.* Galton: *Inquiries into Human Faculty.* Galton: *Natural Inheritance*; p. 259. Galton and Schuster: *Noteworthy Families.* Henderson: *Text Book in the Principles of Education*; Chaps. II. and III. Mark: *Unfolding of Personality*; Introduction and Chap. I. Pearson: *On the laws of Inheritance in Man*; *II. On the Inheritance of the Mental and Moral Characters in Man*; *etc.*, Biometrica, III., Part II., pp. 131-190. Reid: *The Laws of Heredity.* Thorndike: *Educational Psychology*; Chaps. IV., V. and VII. Thorndike: *Measurements of Twins.* Ward: *Applied Sociology*; part on Achievement. Watson: *Heredity.* Woods: *Mental and Moral Heredity in Royalty.*

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[1] R. S. Woodworth: *Racial Differences in Mental Traits*; Science, New Series, Vol. V. pp. 81-88

CHAPTER II.

THE PHYSICAL GROWTH OF THE CHILD.

MAN, when compared with some animals, seems to be at a great disadvantage. The horse is stronger and swifter; the hawk possesses far more acute vision; and the dog has a keener smell. Yet man, slight in stature, weak in strength, and deficient in sensory powers is the highest product of organic evolution. And the reason for this is that in his growth and development he produces a greater proportion of nerve matter, in relation to other bodily tissues, than any other animal. The growth and development of nerve cells is a very slow process and hence the infancy of man—the period of growth and development—is longer, comparatively speaking, than that of any other animal. Since this period is so closely associated with the problem of growth, it will perhaps be wise to spend some time on its discussion and elucidation.

Infancy. Different writers attach different meanings to the term infancy: to some infancy is the period of helplessness; to others it is the period in which physical growth takes place; while to a third section it is synonymous with the period of economic dependence. Thus, according to these views, the period of infancy ranges from one to twenty-five or even thirty years. Thorndike[1] divides up the period of physical growth of man into the following stages:

Infancy	birth to $1 \pm \frac{1}{4}$	
Babyhood	$1 \pm \frac{1}{4}$ to 5 ± 1	
Childhood	5 ± 1 to 12 ± 1	
Transition	12 ± 1 to 14 ± 1	One year earlier for girls.
Early Adolescence	14 ± 1 to $18 \pm ?$	
Late Adolescence	$18 \pm ?$ to $25 \pm ?$	

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[1] *Notes on Child Study*; p. 13.

Clouston[1] subdivides life into :

Childhood - -	birth to 7
Boyhood and Girlhood	7 to 15
Adolescence -	15 to 25
Manhood and Womanhood - -	25 to 55
Decadent Period	55 to death

With respect to infancy three questions may pertinently be discussed : (1) Why should there be a rejuvenation of man at all ? (2) Why should man be born so helpless ? and (3) Why should the period of infancy be so long ? The second and third are seen to be closely related, and may be answered together.

(1) The fact of infancy is so familiar that it is difficult to conceive anything different which could take its place. Yet it seems a wasteful process. From all points of view it would seem to be far more economical to the race for man to go on developing for ever. Apparently it is a "setting back of the clock," for only through painful struggles do children reach the point of development attained by their parents. Decay, which ends in death, oftenest sets in just when man has become of the greatest service to society, when he has reached his maximum development, and when he has changed from being merely a receiver, both of goods and ideas, into a producer and giver. Age, however, brings with it an increasing rigidity both of mind and body, which is reflected in decreasing physical activity and in increasing conservatism of thought. Infancy, on the other hand, is the period of plasticity and adaptability *par excellence*. The rigidity of age means a widening gulf between the organism and its environment. Old people are notoriously bad at adapting themselves to the changing world. Hence age makes progress difficult or impossible. At this point the rejuvenation of the race takes place and saves it from decrepitude and destruction. Infancy is thus the means of exit when age has become a bar to progress. The young alone are able to adapt themselves to the progressive evolution of the race.

(2) and (3). In the lowest animals there is nothing that can justly be called infancy. To all intents and purposes the amoeba is born grown-up. The two daughter amoebae are exactly like the parent in every particular except size. As we ascend the animal scale we find that a real infancy develops although in many animals it is comparatively short. A chicken can peck and fend for

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[1] *The Hygiene of Mind* ; London, 1906.

itself as soon as it is hatched ; a calf can stand as soon as it is born ; while kittens and puppies, although helpless at first, soon develop beyond the need for parental care. With the higher apes and man the need for parental care and oversight extends over a considerable portion of life. Fiske places it for man at almost one-third the natural span. In general, therefore, we may say that the higher the animal the more helpless it is at birth and the longer is its period of infancy. This is shown in the subjoined Table 2.

TABLE 2.

Comparative Adolescence and Longevity (abridged and adapted from A. F. Chamberlain : *The Child* : *a study in the evolution of Man*, p. 8).

Animal.	Authority.	Length of Adolescence.	Length of Life.	Ratio of Length of Life to Length of Adolescence.
Dormouse, -	Hollis.	3 months.	4–5 years.	16–20
Guinea-pig, -	Flourens ; Hollis.	7 ,,	6–7 ,,	10·2–12
Cat, - -	Mivart.	1 year.	12 ,,	12
Cat, - -	Jennings.	2 years.	15 ,,	7·5
Goat, - -	Pegler.	1¼ ,,	12 ,,	9·6
English Cattle, -	Hollis.	2 ,,	18 ,,	9
Large Dogs,	Dalziel.	2 ,,	15–20 ,,	7·5–10
Hippopotamus, -	Chambers' *Encyclopaedia.*	5 ,,	30 ,,	6
Lion, - -	Mivart.	6 ,,	30–40 ,,	5–6·6
English Horse (Hunter), -	Blaine ; Hollis.	6¼ ,,	35 ,,	5·6
Camel, -	Flourens.	8 ,,	40 ,,	5
Man, -	Buffon.	25 ,,	90–100 ,,	3·8–4
Man (Englishman), -	Hollis.	25 ,,	75 ,,	3
Elephant, -	Darwin.	30 ,,	100 ,,	3·3
Elephant, -	Holder, etc.	35 ,,	120 ,,	3·4

The reason for this seems to be two-fold. Man has been selected because of brain-power and as a result of this selection, life has become enormously complex. To meet life's complexity man is now forced to have complex mental powers. While man's physical body has hardly evolved beyond that of the simian, his mental powers are separated by a gap which is immeasurably great. Mental power is dependent upon a slow-developing nervous tissue, hence the period of gestation, long as it is, is totally inadequate for its complete growth. An infancy, with plasticity as its main feature, has therefore developed. This period of infancy is constantly extending as civilisation advances and more than one sociologist has feared the ultimate consequences to the race. Society, in a vague and undefined fashion, now realises the situation which infancy forces on us, and tries to make provision for it. Factory Acts prohibiting child labour, and Education Acts compelling children to attend school are the legislative results of this realisation. It is not a far cry in history from Peel's "Health and Morals of Apprentices Act" of 1802 to the "Scotch Education Act" of 1908, yet the difference in social conscience as represented by the two measures is great beyond compare.

Secondly, infancy is a period for selecting desirable and eliminating undesirable inherited tendencies. For not all of nature's gifts are unmixed blessings; harmful atavistic traits often persist. By this selection, infancy adapts the child to a changing environment and makes him a fitter subject than his parents before him.

Another aspect of infancy of great sociological importance is its supreme moral significance. It was the helplessness of infancy that created the family, and the bond of the family is the one permanent moral basis of society.

Growth. By growth is meant increase of size. A child grows; a crystal, a bank-balance, a snowball, all are said to grow. In the latter cases the growth is by *accretion*: in the special case of the crystal successive layers of solid matter are deposited from solution in regular fashion around a central nucleus and, so long as a constant strength of solution is maintained, there is no reason why the crystal should not go on growing indefinitely. In the case of the child the increase in size is due to two factors, first an actual increase in the number of the cells composing the body; secondly to an increase in their size. Thus the unit of growth in the organism is the cell. A cell grows by *intussusception*, that is, by the absorption of food material in solution through the walls of the cell. But, owing to the fact that the volume of a cell increases more rapidly than its absorbing surface, the growth of a single cell can never go on indefinitely; the starvation point is soon reached. The process which prevents such a calamity happening is that known as *fission*, whereby a cell divides into two daughter-cells each approximately one-half the size of the parent. Cells grow old, lose in weight and finally die. Hence the apparent rate of growth of a child is the true rate of growth minus an amount due to atrophy of cells. In infancy the balance is plus; in senile decay the balance is minus; while in middle life a general state of equilibrium is preserved.

The ultimate size to which a child grows seems to be pre-ordained by nature. It is difficult to prevent a boy whom nature intended to be a six-foot man from attaining that size. Starvation and sickness have some effect, but if these hindrances are removed, the recuperative power of the body is often found to be enormous.

Growth and Development. The distinction between growth and development is that growth is quantitative, while development is qualitative and depends upon a change in the constitution of the cells. Growth and development are, however, closely associated. They are almost contemporaneous, although growth usually takes place first. If we exercise the biceps muscle it grows bigger and hardens. The hardening is the development. Nerve cells and certain other cells of the body chiefly grow before they develop, but if, after growth, they are not developed, they tend to atrophy.

The Measurement of Growth in Children. Two kinds of error are liable to occur in the measurement of growth in children. The first is the failure to preserve constant conditions in the actual measuring process. For example, in measuring height, children are apt to "stretch up"; the horizontal bar which is part of the standard for measuring heights is apt to slip and to make an angle greater or less than 90° with the upright; children's hair, especially that of girls, tends to get in the way; and the measuring bar tends to be pushed down either too tightly or too lightly upon the heads of the children. A combination of such errors as the above could easily give a final result at least an inch from the true one. Other things that may be overlooked are the necessity for taking heights without boots, and weights with clothing including boots, although the practice has arisen in England, since the advent of medical examination of school children, of taking both heights and weights without boots. Boots, however, are clearly part of the clothing. In measuring "sitting height," chest girth, vital capacity, cephalic index (ratio of breadth to length of head), and circumference of head even greater precautions are needed.

The second type of error is in the interpretation of the results. A training in statistical work is not only desirable but absolutely essential if errors of this kind are to be avoided. The following are some of the errors likely to be made in interpreting statistics of height:

1. The assumption that the difference between the average heights of six year and seven year old boys represents the average growth for one year. This is not necessarily the case unless the same set of boys were measured after an interval of a year. The seven-year-olds are less numerous than the six-year-olds because some of the six-year-olds have died before the age of seven is reached. The result is unaltered if the children who die are of normal height. If they are taller than the average, the registered growth for the year is too small; if they are smaller, the result is too great. There is some ground for believing that the latter condition usually holds.

2. Failure to get homogeneous groups. It will be shown later in the chapter that height is affected by race, social position of parents and so forth.

3. The attendance of poor children at the elementary school is not so regular as that of the more well-to-do; hence the average height of school children is affected by the more frequent inclusion of the measurements of the latter class. The same line of argument applies to the sickly children as opposed to the healthy ones. Both factors tend to make the results too high.

4. Children whose age was eight last birthday are often put down as 8·5 years of age. A curious fallacy may creep in owing to the fact that more children of 9-11 years of age attend school than any other. The reason is that the sickly ones do not begin to attend until 7 or 8, while those of 12 and 13 are already beginning to leave. This fact causes the average ages of all 11, 12 and 13 year old school children to be less than 11·5, 12·5 and 13·5, while the average ages of 6, 7, 8 and 9 year-olds are greater than 6·5, 7·5, 8·5 and 9·5 respectively.

Factors influencing the Growth of Children. The main factors are age, sex, heredity (race), disease and nutrition (social position). Other factors of minor importance are exercise, place of residence (climate), order of birth, time of year, time of week, and time of day.

Age. In general, it is true to say that children grow absolutely and relatively more quickly the younger they are. From impregnation to birth a child grows 905,600,000-fold in weight. The rate of growth diminishes, with the exception of a few spurts, from the beginning of life to the moment of death. Hence the truth of the statement "we begin to die as soon as we are born."

TABLE 3.

Table showing average height, weight, chest-girth and span of arms of both sexes in British Isles at different ages (from Report of Anthropometric Committee of British Association, p. 294).

Age last Birth-day.	Height without shoes in inches.		Weight with clothes in lbs.		Chest-girth empty in inches.		Span of arms across the back in inches.	
	M.	F.	M.	F.	M.	F.		F.
Birth	19·52	19·31	7·1	6·9	13·25	12·65	..	..
*0–1	27·00	24·83	..	..	..	..	..	..
*1–2	33·50	27·50	..	..	..	..	..	..
*2–	33·70	32·33	32·5	..	..	..	..	..
3–	36·82	36·05	34·0	31·9	..	..	..	..
4–	38·46	38·13	37·3	35·5	..	..	..	..
5–	41·03	40·82	39·9	39·6	..	..	..	..
6–	44·00	42·63	44·4	42·4	..	..	..	..
7–	45·97	44·45	49·7	46·7	..	..	43·10	45·83
8–	47·05	46·60	54·9	52·2	..	..	47·56	46·50
9–	49·70	48·73	60·4	55·5	..	..	49·07	48·39
10–	51·84	51·05	67·5	62·0	26·10	..	50·64	49·92
11–	53·50	53·10	72·0	68·1	26·53	..	51·98	52·41
12-	54·99	55·66	76·7	76·4	27·20	..	54·03	55·04
13	56·91	57·77	82·6	87·0	28·03	..	55·51	58·06
14–	59·33	59·80	92·0	96·7	28·46	..	57·15	59·04
15	62·24	60·93	102·7	104·8	29·74	..	..	60·79
16–	64·31	61·75	119·0	112·7	31·53	..	..	61·66
17–	66·24	62·52	130·9	114·9	33·64	..	..	62·52
18–	66·96	62·44	137·4	117·7	34·19	..	..	62·50
19–	67·29	62·75	139·6	123·7	34·49	..	..	62·69
20–	67·52	62·98	143·3	123·2	34·98	..	..	62·49
21–	67·63	63·03	145·2	121·2	35·25	..	..	62·19
22–	67·68	62·87	146·9	124·2	35·33	..	..	62·35
23–	67·48	63·01	147·8	126·4	35·62	..	..	62·36
24–	67·72	62·70	148·0	120·6	35·82	..	..	62·22

NOTE.—The figures for ages marked * are extremely doubtful because so few cases were taken.

TABLE 4.

Table showing the average height and weight of American children at different ages (from Boas : *Growth of Toronto Children*, U.S. Education Commissioner's Report, II. 1896-7, pp. 1555-6, and Burk : *Growth of Children in height and weight* ; American Journal of Psychology, April, 1898, pp. 262-3).

Approximate average age.	Male.		Female.		Height in inches.		Weight in lbs.		Absolute annual increase of height in inches.		Absolute annual increase of weight in lbs.	
	Height in cms.	Mean variation.	Height in cms.	Mean variation.	M.	F.	M.	F.	M.	F.	M.	F.
5·5	105·90	±4·40	104·88	..	41·7	41·3	..	..	..	..	..	..
6·5	111·58	±4·66	110·08	±4·78	43·9	43·3	45·2	43·4	2·2	2·0	..	..
7·5	116·83	±5·00	116·08	±5·01	46·0	45·7	49·5	47·7	2·1	2·4	4·3	4·3
8·5	122·04	±5·34	121·21	±5·46	48·8	47·7	54·5	52·5	2·8	2·0	5·0	4·8
9·5	126·91	±5·48	126·14	±5·54	50·0	49·7	59·6	57·4	1·2	2·0	5·1	4·9
10·5	131·78	±5·74	131·27	±6·00	51·9	51·7	65·4	62·9	1·9	2·0	5·8	5·5
11·5	136·20	±6·20	136·62	±6·63	53·6	53·8	70·7	69·5	1·7	2·1	5·3	6·6
12·5	140·74	±6·62	142·52	±7·41	55·4	56·1	76·9	78·7	1·8	2·3	6·2	9·2
13·5	146·00	±7·54	148·69	±7·20	57·5	58·5	84·8	88·7	2·1	2·4	7·9	10·0
14·5	152·39	±8·49	153·50	±6·57	60·0	60·4	95·2	98·3	2·5	1·9	10·4	9·6
15·5	159·72	±8·61	156·50	±5·88	62·9	61·6	107·4	106·7	2·9	1·2	12·2	8·4
16·5	164·90	±7·63	158·03	±5·65	64·9	62·2	121·0	112·3	2·0	0·6	13·6	5·6
17·5	168·91	±7·15	159·14	..	66·5	62·7	..	115·4	1·6	0·5	..	3·1
18·5	171·07	..	..	..	67·4	..	..	114·9	0·9	..	..	..

TABLE 5.

Relative Weight and Height Table for Boys. The figures represent weight in lbs. without clothing. (From Wood : *Health and Education* ; 9th year-book of the National Society for the Study of Education.)

Height in inches.	Age in Years.															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
39	35	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
40	38	36	..	..	..	..	..	..	..	..	..	..	..	..	..	..
41	39	39	..	..	..	..	..	..	..	..	..	..	..	..	..	..
42	41	41	..	..	..	..	..	..	..	..	..	..	..	..	..	..
43	42	42	42	..	..	..	..	..	..	..	..	..	..	..	..	..
44	46	44	43	..	..	..	..	..	..	..	..	..	..	..	..	..
45	..	46	46	45	..	..	..	..	..	..	..	..	..	..	..	..
46	..	48	48	48	..	..	..	..	..	..	..	..	..	..	..	..
47	..	..	49	50	50	..	..	..	..	..	..	..	..	..	..	..
48	..	..	54	53	53	53	..	..	..	..	..	..	..	..	..	..
49	..	..	..	54	55	55	..	..	..	..	..	..	..	..	..	..
50	..	..	..	57	58	58	..	..	..	..	..	..	..	..	..	..
51	..	..	..	59	60	60	61	..	..	..	..	..	..	..	..	..
52	..	..	..	..	62	62	61	63	..	..	..	..	..	..	..	..
53	..	..	..	..	62	65	65	67	67	67	..	..	..	..	..	..
54	..	..	..	..	65	68	68	70	71	71	..	..	..	..	..	..
55	..	..	..	..	..	69	71	75	75	76	..	..	..	..	..	..
56	..	..	..	..	..	71	77	76	78	79	79	..	..	..	..	..
57	..	..	..	..	..	..	77	79	80	82	82	..	..	..	..	..
58	..	..	..	..	..	..	78	84	85	86	87	..	..	..	..	..
59	..	..	..	..	..	..	..	84	86	90	91	..	..	..	..	..
60	..	..	..	..	..	..	..	85	91	94	95	90	..	..	..	..
61	..	..	..	..	..	..	..	..	98	97	99	96	..	..	..	..
62	..	..	..	..	..	..	..	..	99	103	106	104	104	..	..	..
63	..	..	..	..	..	..	..	..	100	107	112	112	110	118	..	..
64	..	..	..	..	..	..	..	..	..	114	118	120	117	120	120	..
65	..	..	..	..	..	..	..	..	..	122	119	122	122	120	126	125
66	..	..	..	..	..	..	..	..	..	..	121	125	125	126	129	130
67	..	..	..	..	..	..	..	..	..	..	128	129	128	131	136	136
68	..	..	..	..	..	..	..	..	..	..	133	133	130	136	136	136
69	..	..	..	..	..	..	..	..	..	..	..	134	136	139	139	139
70	..	..	..	..	..	..	..	..	..	..	..	136	140	143	144	145
71	..	..	..	..	..	..	..	..	..	..	..	..	140	146	146	146
72	..	..	..	..	..	..	..	..	..	..	..	..	..	..	149	154
73	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	165

From Tables 3 and 4 it will be seen that the average child at birth has a stature of about 19½ inches and a weight of about 7 lbs. Growth in height practically ceases at 25 for men and at 23 for women, although the average amount of growth in the last four or five years is extremely small and may be due, in part, to a selective death rate among individuals. Growth in weight may continue to middle age, although it is doubtful if increase after 25-30 is normal.

TABLE 6.

Relative Weight and Height Table for Girls.

Height in inches.	Age in Years.															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
39	34	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
40	37	35	..	..	..	..	..	..	..	..	..	..	..	..	..	..
41	38	37	..	..	..	..	..	..	..	..	..	..	..	..	..	..
42	41	39	39	..	..	..	..	..	..	..	..	..	..	..	..	..
43	41	41	42	..	..	..	..	..	..	..	..	..	..	..	..	..
44	45	43	44	42	..	..	..	..	..	..	..	..	..	..	..	..
45	..	45	45	45	..	..	..	..	..	..	..	..	..	..	..	..
46	..	48	47	47	..	..	..	..	..	..	..	..	..	..	..	..
47	..	..	50	49	49	..	..	..	..	..	..	..	..	..	..	..
48	..	..	..	51	51	..	..	..	..	..	..	..	..	..	..	..
49	..	..	..	53	53	54	..	..	..	..	..	..	..	..	..	..
50	..	..	..	56	56	57	..	..	..	..	..	..	..	..	..	..
51	..	..	..	..	59	58	60	..	..	..	..	..	..	..	..	..
52	..	..	..	..	63	62	62	63	..	..	..	..	..	..	..	..
53	..	..	..	..	..	64	63	66	65	..	..	..	..	..	..	..
54	..	..	..	..	..	69	68	69	68	..	..	..	..	..	..	..
55	..	..	..	..	..	..	70	71	73	..	..	..	..	..	..	..
56	..	..	..	..	..	..	75	75	76	78	..	..	..	..	..	..
57	..	..	..	..	..	..	..	78	80	83	..	..	..	..	..	..
58	..	..	..	..	..	..	..	83	86	88	89	..	..	..	..	..
59	..	..	..	..	..	..	..	88	89	93	97	100	..	..	..	..
60	..	..	..	..	..	..	..	94	94	96	100	104	109	103	99	99
61	..	..	..	..	..	..	..	..	99	100	102	109	109	106	105	111
62	..	..	..	..	..	..	..	..	104	104	106	111	110	107	111	114
63	..	..	..	..	..	..	..	..	..	107	109	116	110	112	113	114
64	..	..	..	..	..	..	..	..	..	112	118	116	117	114	119	115
65	..	..	..	..	..	..	..	..	..	114	118	121	125	120	123	125

NOTE.—The table reads thus: A girl of five years of age and 39 inches in height ought, if normal, to weigh 34 lb.

The relationship between heights and weights at different ages is extremely complicated. Tables 5 and 6 are probably the best, for practical purposes, that have yet been made.

Sex. The British Anthropometric Committee in their report (p. 288) come to the following conclusions with respect to the rates of growth of boys and girls :

"(1). From birth to the age of five years the rate of growth is the same in both sexes, girls being a little shorter in stature and lighter in weight than boys.

(2). From 5 to 10 years boys grow a little more rapidly than girls, the difference being apparently due to a check in the growth of girls at these ages.

(3). From 10 to 15 years girls grow more rapidly than boys, and at the ages of 11½ to 14½ are actually taller, and from 12½ to 15½ years actually heavier than boys. This difference appears to be due to a check in the growth of boys as well as an acceleration in the growth of girls incident on the accession of puberty.[1]

(4). From 15 to 20 years boys again take the lead, and grow at first rapidly, and gradually slower, and complete their growth at about 23 years. After 15, girls grow very slowly, and attain their full stature about the twentieth year."

Practically all observers report the same phenomena. The interesting feature, from an educational point of view, about sexual differences in rates of growth is the prepubertal acceleration. Two diametrically opposed conclusions have been arrived at from the same facts. The first is that since physical growth is closely paralleled by mental growth, girls should be given more difficult mental tasks than boys between the ages of 10 and 14. The second view is that there is only a given amount of energy in the body at a given time and consequently, if it is used up in physical growth, it is not available for mental tasks : adolescent girls ought, therefore, to be given only the minimum amount of mental labour. The present state of knowledge prevents us from saying which is the more correct view. Common observation fails to detect any serious differences in mental power between boys and girls of any age.

Heredity or Race. Probably this factor ought to have been placed first, for, as Thorndike says, "the fact that we have men as ancestors decides that we shall, if we reach adult age, not be as small as rabbits or as big as elephants." Our treatment, however, assumes the human inheritance, and the problem then is—how does a different racial inheritance affect growth? The following tables indicate a solution. Table 1 (page 8) ought also to be consulted.

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[1] A better explanation is that the adolescent spurt of girls takes place some two to three years earlier than that of boys.

TABLE 7.

Table showing stature of adult males of various races and nationalities. (Abridged from Anthropometric Report of British Association; 1882, p. 269.)

Race or Nationality.	Authority.	Metres.	Inches.
Polynesians, - - - - -	Various.	1·762	69·33
English Professional class, -	Anthropom. Comm.	1·757	69·14
Negroes of the Congo, - -	Topinard.	1·752	68·95
Scotch, all classes, - - -	Anthropom. Comm.	1·746	68·71
North American Indians, -	Baxter.	1·726	67·93
Irish, all classes, - - -	Anthropom. Comm.	1·725	67·90
United States (whites, all classes), - - - - -	Baxter.	1·719	67·67
English, all classes, - -	Anthropom. Comm.	1·719	67·66
Norwegians, immigrants to U.S.A., - - - - -	Beddoe.	1·717	67·62
Swedes, immigrants to U.S.A.,	Beddoe and Baxter.	1·700	66·90
Welsh, all classes, - - -	Anthropom. Comm.	1·695	66·66
American negroes, - - -	Baxter.	1·693	66·62
Australian aborigines, - -	Various.	1·669	65·68
Japanese, - - - - -	Ayrton.	1·604	63·11
Lapps, - - - - - -	Horch.	1·500	59·2
Bosjesmans (Bushmen and S. Africa), - - - -	Various.	1·341	52·78
Difference between the tallest and shortest races, -		·421	16·55
Average stature of man according to above, - -		1·658	65·25

It is probably correct to assume that the shorter races have a slower rate of growth, although the fact that tropical peoples mature earlier, that is, complete their growth in a fewer number of years, will tend to hide the fact. The tallest race is the Polynesian of Samoa; the smallest is the Bushman of Africa. The difference between the average of the shortest and tallest races is less than that between individuals of the same race. The order of magnitude in stature is, for the races of the British Isles, Scotch Irish, English, Welsh; and for weight, Scotch, Welsh, English, Irish. The differences, especially for height, are somewhat small.

TABLE 8.

Table showing the weight of 7,749 adult males of the population of the United Kingdom, arranged according to place of birth. (Adapted from Anthropometric Report, British Association; 1883, p. 256.)

Weight with Clothes.		Number of Men within given Limits of Weight. Place of Birth.				Total.
Lbs.	Kilos.	England.	Scotland.	Wales.	Ireland.	
90	40·9	2	..	..	..	2
100	45·5	26	1	2	5	34
110	50·0	133	8	10	1	152
120	54·5	338	22	23	7	390
130	59·1	694	63	68	42	867
140	63·6	1240	173	153	57	1623
150	68·2	1075	258	178	51	1559
160	72·7	881	275	134	36	1326
170	77·3	492	168	102	25	787
180	81·8	304	125	34	13	476
190	86·4	174	67	14	8	263
200	90·9	75	24	7	1	107
210	95·5	62	14	8	1	85
220	100·0	33	7	1	..	41
230	104·5	10	4	2	..	16
240	109·1	9	2	..	..	11
250	113·6	3	4	1	..	8
260	118·2	1	..	..	..	1
270	122·7	..	..	..	..	..
280	127·3	..	..	1	..	1
Total, - -		5552	1212	738	247	7749
Average in lbs.,		155·0	165·3	158·3	154·1	158·2

Disease and Overpressure. Most diseases retard growth. Recovery from disease is followed by an accelerated rate of growth. The healthiest growth is that which takes place at normal times and at normal rates. Hence heights and weights are exceedingly useful indications of the state of health. School children ought to be weighed from four to six times a year.

Overpressure has the same effect as disease. In the Fielden School, in connection with Manchester University, the weights of the children were found to decrease during term time. The deficiency was more than made up during holidays, hence it was assumed that the school-work was too arduous. This led to a lightening of the tasks, with most beneficial results to the children concerned. Many observers state that the periods of rapid growth are the periods of freedom from disease, but the records are not unanimous.

Nutrition. Nutrition is largely dependent upon the social position of the parents. This, however, is not invariably the case. Poor Scotch children are probably better fed than better class artisan English children. Imperfect nutrition, as the subjoined tables show, decreases the rate of growth. But it is probable that it affects development more than growth.

TABLE 9.

Table showing the relative statures of boys of the age 11 to 12 years, under different social and physical conditions of life. (Adapted from Anthropometric Report of British Association; 1883, p. 283.)

Class of School.		Average height in inches.
Public Schools in country districts,		54·98
Middle Class Schools in towns	Upper	53·85
	Lower,	53·70
Elementary Schools	Country,	53·01
	Town,	52·60
Factories and Workshops	Country,	52·17
	Town,	51·56
Industrial Schools,		50·02

Bowditch[1] found that boys attending certain schools in Boston, the attendance at which indicated the probability that they represented a favoured class, were about an inch taller and from 4 to 10 lbs. heavier than the average of the population.

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[1] H. P. Bowditch: *The Growth of Children*; Eighth Annual Report of the State Board of Health of Massachusetts.

TABLE 10.

Table showing the relative statures of adults of the ages of 25 to 30 years under different social and physical conditions of life. (Adapted from Anthropometric Report of British Association; 1883, p. 284.)

Social Class.	Average height in inches.
General Population: all classes, - - - -	67·43
Class I.: Professional classes, - - - -	69·14
Class II.: Commercial classes, clerks and shopkeepers, - - - - - - - -	67·95
Class III.: Labouring classes: Agricultural, Miners, Sailors, - - - - - -	67·51
Class IV.: Artisans in towns, - - - -	66·61
Class V.: Sedentary occupations: Factories, Tailors, - - - - - - - -	65·92
Class VI. (*a*): Prisoners, all classes, - - -	66·16
(*b*): Lunatics, all classes, - - -	65·65

Exercise. The result of exercise is to tone up the muscles and to increase the effectiveness of the circulatory and excretory systems of the body. All parts of the body are better fed and the waste products of oxidation and decomposition are rapidly eliminated. These things favour growth. Whether exercise in excess favours growth is exceedingly doubtful. It is as easy, especially in England, to get into the habit of exercise and games as it is to get into the habit of smoking or drinking. Much less exercise is necessary to keep the body fit in a physiological sense, than is generally supposed. And, in the case of girls, medical opinion is steadily growing stronger against vigorous exercise during adolescence, such as is obtained by hard games of hockey. Girls must be anabolic during this period, that is, the body must store up food for the emergencies of later life. Vigorous exercise tends to make them katabolic, wasteful of energy, like boys, and it is doubtful if this is beneficial in the long run. A milder form of exercise would seem to favour the growth of girls.

Place of Residence (Climate). Generally speaking, residence in the temperate parts of the world seems to favour growth, for it is in these parts that the bulk of the bigger races are found. It is impossible, in the present state of knowledge, to say whether a child of a big race would grow more slowly if removed to the torrid or frigid zones, but the probabilities are that he would.

Order of Birth. Little information has been gathered on this point. *A priori* reasoning would lead us to expect that first-born children would be bigger than others for they are usually born during the period of greatest vigour of the parents, especially of the mother, and during the period when food is relatively more plentiful, for it is shared by a smaller number in the family. From measurements given below it would seem that such is the case, although the amounts both for heights and weights are extremely small.

TABLE 11.

Table showing the influence of order of birth upon the height and weight of children in Oakland, Cal. (Adapted from Boas: *Growth of Toronto Children*; U.S. Education Commissioners' Report II., 1896-7, pp. 1569-70.)

Order of birth.	Height. Increase or decrease (in mms.) from general average of population (ages 6–16 years).		Weight. Increase or decrease (in lbs.) from general average of population (ages 6–16 years).	
	M.	F.	M.	F.
First-born, -	4·5	7·1	0·82	1·12
Second-born, -	4·0	−2·8	0·60	0·48
Third-born, -	1·9	−4·5	0·32	−1·71
Fourth-born, -	−7·9	−3·3	−1·58	−0·72
Later-born, -	−6·9	−2·3	−0·44	−0·12

NOTE.—The table reads thus: between the ages of 6 and 16, boys, if first-born, are on the average 4·5 mms. taller and ·82 lbs. heavier than the general average of the population.

Time of Year. Malling-Hansen[1] found that the period of greatest growth in weight for boys was from August to the middle of December, while the period of least growth was from the beginning of May to the end of July. The maximum growth in height was from April to the middle of August; the minimum from August till near the end of November. Thus boys grow alternatively in height and weight. These results have not been confirmed.

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[1] *Perioden im Gewicht der Kinder und in der Sonnenwärme.*

Time of Week. Vierordt[1] found weekly fluctuations but there is no conclusive evidence on the point. Medical men, however, report that children's bilious attacks are more numerous after the heavy Sunday dinner than at other times, and hence growth during the early part of the week tends, for these children, to be arrested.

Time of Day. From the time of rising to the time of going to bed a person's height tends to decrease. This is due to the compression of the elastic cushions of cartilage found between each pair of vertebrae of the spinal column. The difference is usually about half-an-inch. Measurements of height are, for this reason, best taken about noon. As measurements of weight are by far the best indications of the state of the health of children, these differences in height are not so serious, except on the grounds of statistical uniformity.

Growth of Parts. If all parts of the body grew in equal ratios an adult would be a monstrosity for he would reproduce the large head and short legs of the baby. The following table, abridged from Vierordt's *Physiologie des Kindesalters* (p. 254), shows the relative growth in weight of certain organs from birth to maturity:

	fold.		fold.
Muscles	48	Liver	13·6
Pancreas	28	Heart	12·5
Skeleton	26	Kidneys	12
Lungs	20	Spinal cord	7
Stomach and alimentary canal	20	Brain	3·7
		Eye	1·7

Sex differences in the growth of parts, especially of the skeleton and muscles, are also most marked. The whole problem is exceedingly difficult and exactly what harmonious development means, nobody at present can say.

Physique and Mental Ability. The studies referred to in the footnote below bear upon the question—"Are bigger children more capable, mentally, than the less favoured ones?" but the conclusions reached are most conflicting.[1]

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[1] *Physiologie des Kindesalters,* in Gerhardt's *Handbuch der Kinderkrankheiten,* Vol. I.

Porter, using coarse age and grade groupings, found that large children are intellectually superior to small ones. Beyer also found a positive correlation between physique and mental ability, while Boas found in Toronto that "the children pronounced by the teacher bright were less favourably developed than those called dull." "Galton found eminent English men of Science to be half an inch taller than their fathers."[2] College students are taller than the average of the population. The evidence is so conflicting that it is difficult to say on which side the truth lies. It is very probable that there is a slight positive correlation between physique and mental ability. This should lead to feelings of satisfaction when children are found to be above the average both in height and weight.

References. Butler: *Meaning of Education*; Chap. I. Chamberlain: *The Child.* Drummond: *Ascent of Man*; Chap. IV. Drummond: *The Child.* Fiske: *The Meaning of Infancy.* Hall: *Adolescence*; Chaps. I.-III. Kirkpatrick: *Fundamentals of Child Study.* Reid: *Laws of Heredity*; Chap. I. Thorndike: *Notes on Child Study*; Chaps. III. and VI. Tyler: *Growth and Education.* Wells: *Mankind in the Making.* Whipple: *Manual of Mental and Physical Tests*; Chap. IV. Wood: *Health and Education*; Chap. I.

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[1] Porter: *Transactions of the St. Louis Academy of Science*; VI., 161 ff.

Gilbert: *Yale Studies*, Vol. II., and *University of Iowa Studies*, Vol. I.

Boas: *Science, New Series*, IV., pp. 225-230.

West: *Science, New Series*, IV., pp. 156-159.

Beyer: *Journal of the Boston Medical Society*, 1900.

[2] Thorndike: *Educational Psychology*; 1st Ed., p. 145.

CHAPTER III.

THE STATISTICAL TREATMENT OF EDUCATIONAL MEASUREMENTS.[1]

In the preceding chapter attention was directed to the necessity of interpreting carefully the results of educational measurements in order to prevent erroneous conclusions from being reached. The aim of the present chapter is to give an exposition of the treatment of the simpler statistical summaries.

In the physical sciences the development of measurement has been a comparatively simple affair, although the invention of satisfactory electrical standards gave physicists a great amount of trouble. The task was, however, simplified by the kind of things the scientists had to measure—constants for the most part. Length and weight, the principal objects of their attention, are constant under constant conditions. And fairly constant conditions are relatively easy to obtain. Even errors of observation could be estimated and allowances made. But when we come to measurement of variable objects and phenomena, such as are illustrated by mental traits in animals (with man as the highest type), the task is complicated in many ways. In the first place, we have no standards—at least, no objective standards—which can be used as measuring sticks ; in the second place, the things we measure are constantly varying because we cannot preserve or re-establish identical conditions. What standards can we use in measuring memory or piety, or excellence in school subjects ? How impossible it is to make the memory of to-day equal to the memory of yesterday! Memory is a variable quantity. And so with all mental traits.

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[1] Portions of this chapter have appeared in *The Journal of Experimental Pedagogy* and are now reprinted by kind permission of the Editor. The chapter should be used for reference purposes only.

As measurement in education is chiefly concerned with measurement of mental traits, the problem reduces itself to measurement of variable quantities, the results of which must be treated statistically before the mind can grasp their significance. Recent text-books in education, and especially those in the field of educational psychology, are filled with formulæ and statistics illustrative of modern attempts to introduce measurement into this field. These formulæ and statistical results often appear difficult, but they are not really so; the difficulty disappears as soon as they become intelligible. The absence of elementary, non-mathematical text-books on statistics has been the chief source of the trouble, but this deficiency bids fair to be remedied in the near future.

Before proceeding to the definitions and calculations it may be as well to point out some of the difficulties in the way of measurement in education. These are: (1) Difficulty of the units of measurement used. The unit for spelling, one word; for arithmetic, one example; for school-administration, one scholar; for auditory memory, one word remembered, are all fictitious. Unequal things are counted as equal because they are possessed of the same name. As for school marks in general they are quite arbitrary, and not only does the standard vary between different conditions, but also at different times. Further, we have no units at all for measuring the degree of goodness, or badness, or timidity, or even the merit of handwriting or drawing. (2) The difficulty that numbers representing measures of mental traits seldom stand for exact quantities. For example, 5 may represent from 4·5 to 5·5 as in the measurement of length, measurement of reaction times, or in measurement of wealth in pounds sterling; 5 may mean from 5 to 6 as in the matter of problems right in an arithmetical test, or in the number of words remembered in a memory test; and 5 may also mean from 4 to 5 as in the recording of errors made in drawing one line equal to another, or in the recording of times in races. The third method, that of the point just not reached, seldom occurs in educational measurements; the second, where 5 stands for 5 to 6, is by far the most common. "It is necessary to get into the habit of thinking of figures as measures on a

TABLE 12.

Heights and Weights of 50 Manchester Grammar School Boys. (Mumford.)

(1) No.	(2) Height in inches.	(3) Deviations. d_1 or x.	(4) d_1^2 or x^2.	(5) Weights in lbs.	(6) Deviations d_2 or y.	(7) d_2^2 or y^2.	(8) d_1d_2 or $x.y$.	(9) g.
1	53	−6	36	61·5	−38·5	1482·25	+ 231	..
2	53·25	−5·75	33·06	64·5	−35·5	1260·25	+ 204·12	..
3	54·75	−4·25	19·06	76	−24	576	+ 102	..
4	56	−3	9	84	−16	256	+ 48	..
5	56·75	−2·25	5·06	77·5	−22·5	506·25	+ 50·625	..
6	57·5	−1·5	2·25	75	−25	625	+ 37·5	1
7	57·5	−1·5	2·25	78	−22	484	+ 33	..
8	57·75	−1·25	1·56	87·5	−12·5	156·25	+ 15·62	..
9	57·75	−1·25	1·56	88·5	−11·5	132·25	+ 14·375	..
10	58	−1	1	74	−26	676	+ 26	6
11	58	−1	1	81	−19	361	+ 19	..
12	58	−1	1	82·5	−17·5	306·25	+ 17·5	..
13	58	−1	1	92	− 8	64	+ 8	..
14	58	−1	1	73·5	−26·5	702·25	+ 26·5	11
15	58·25	− ·75	·56	75	−25	625	+ 18·75	9
16	58·5	− ·5	·25	82·5	−17·5	306·25	+ 8·75	2
17	58·5	− ·5	·25	94	− 6	36	+ 3	..
18	58·5	− ·5	·25	81	−19	361	+ 9·5	6
19	58·5	− ·5	·25	90	−10	100	+ 5	..
20	58·5	− ·5	·25	86·5	−13·5	182·25	+ 6·75	..
21	58·75	− ·25	·06	83	−17	289	+ 4·25	6
22	59·5	+ ·5	·25	84	−16	256	− 8	5
23	59·5	+ ·5	·25	95	− 5	25	− 2·5	..

24	59·75	+ ·75	·56	107	+ 7	49		+ 5·25	..
25	60	+1	1	87·25	−12·75	162·56	−12·75		3
26	60	+1	1	89	−11	121	−11		1
27	60	+1	1	91·5	− 8·5	72·25	− 8·5		..
28	60	+1	1	87	−13	169	−13		7
29	60·5	+1·5	2·25	92	− 8	64	−12		..
30	61	+2	4	86	−14	196	−28		11
31	61	+2	4	98	− 2	4	− 4		..
32	61	+2	4	92·5	− 7·5	56·25	−15		2
33	61	+2	4	96	− 4	16	− 8		..
34	61·25	+2·25	5·06	75·5	−24·5	600·25	−54·125		27
35	61·25	+2·25	5·06	92·5	− 7·5	56·25	−16·875		4
36	61·5	+2·5	6·25	101	+ 1	1		+ 2·5	..
37	61·5	+2·5	6·25	99	− 1	1	− 2·5		1
38	61·75	+2·75	7·56	102	+ 2	4		+ 5·5	..
39	62	+3	9	99	− 1	1	− 3		2
40	62·25	+3·25	10·56	106·5	+ 6·5	42·25		+ 21·125	..
41	62·25	+3·25	10·56	104	+ 4	10		+ 13	..
42	63	+4	16	118	+18	324		+ 72	6
43	64·5	+5·5	30·25	85	−15	225	−82·50		25
44	64·75	+5·75	33·06	102	+ 2	4		+ 11·5	3
45	65·25	+6·25	39·06	99	− 1	1	− 6·25		7
46	65·5	+6 5	42·25	105·5	+ 5·5	30·25		+ 35·75	3
47	66·25	+7·25	52·56	124·5	+24·5	600·25		+ 177·625	..
48	67	+8	64	118·5	+18·5	342·25		+ 148	1
49	67·5	+8·5	72·25	134·5	+34·5	1190·25		+ 293·25	..
50	68·75	+9·75	95·06	125	+25	625		+ 243·75	1
			644·77			14642·06	−288·00	+1918·49	150
							+1630·49		

continuous scale representing the quantities between two limits." (3) Mental measurements often exhibit an undistributed zero, *i.e.* a zero which is not absolute, but which may extend for some indefinite distance below a theoretical zero. For example, a group of 1,000 pupils may have a test in the shape of 20 arithmetical examples to be done in a certain time. Some of the pupils will get 20 right, others 19, 18, 17, and so forth to zero. But the pupils who fail to get no examples in arithmetic correct are not of equal degrees of weakness below those who get only one example correct. The zero in this case is undistributed. (4) Mental measurements are usually in a continuous series (as opposed to discrete). Intellect, wealth, reaction-time, timidity, velocity, time, length, weight, goodness and badness are theoretically capable of any degree of subdivision. (6) The difficulty of getting a reliable scale of measurements. Scales are so often the result of an individual's chance bias, or they are influenced by some constant error, or they are not on a sufficiently minute scale.

As was previously stated, mental traits are variable. They are, therefore, best graphically represented by a "surface of frequency" or "distribution curve." Such a surface of frequency was shown in Chapter I. (p. 9).

The preceding table (Table 12) gives in columns (2) and (5) the heights and weights of fifty boys of the Manchester Grammar School between the ages of 14 and 14·25. Boy number 26 was 60 inches in height and 89 lbs. in weight.

Table 13 gives the same information with regard to heights condensed into a table of frequencies.

The table reads that there was one boy of 53 inches, one boy of 53·25 inches, and so forth.

Both tables are obviously clumsy although they have the merit of giving the whole of the available information. Even a graphical representation, such as is given by a surface of frequency, is too cumbrous to use with freedom. Hence numerical summaries of the main features of such tables of measurements have been evolved. Two such statements or representative measures are necessary to give the main facts of the distribution :

1. A number representing the central or general tendency of the measures.
2. A number representing the degree of variability of the measures.

TABLE 13.

Table of Frequencies.

Frequency No. of Boys.	Quantity Heights of Boys.	Frequency No. of Boys.	Quantity Heights of Boys.
1	53	(21) 4	61
1	53·25	2	61·25
0	53·5	(15) 2	61·5
0	53·75	1	61·75
0	54	(12) 1	62
0	54·25	2	62·25
0	54·5	0	62·5
1	54·75	0	62·75
0	55	1	63
0	55·25	0	63·25
0	55·5	0	63·5
0	55·75	0	63·75
1	56	0	64
0	56·25	0	64·25
0	56·5	1	64·5
1	56·75	1	64·75
0	57	0	65
0	57·25	1	65·25
2	57·5	1	65·5
(9) 2	57·75	0	65·75
(14) 5	58	0	66
1	58·25	1	66·25
(20) 5	58·5	0	66·5
1	58·75	0	66·75
0	59	1	67
0	59·25	0	67·25
(23) 2	59·5	1	67·5
(24) 1	59·75	0	67·75
4	60	0	68
0	60·25	0	68·25
(22) 1	60·5	0	68·5
0	60·75	1	68·75

MEASURES OF CENTRAL TENDENCY.[1]

There are three measures of central tendency in common use—the average or mean, the median, and the mode.

---

[1] The fact that the height was determined to the nearest ¼″, and weight to the nearest ½ lb. has not been taken into account in the subsequent calculations. This would unnecessarily complicate matters for beginners

The ordinary arithmetical mean (M) is obtained by dividing the sum of the individual measures (m) by their number (n).

$$M = \frac{\Sigma m}{n}$$

This method is long and tedious. The labour of calculation is minimised if the following method is adopted : " Arrange the numbers in the order of their amount ; choose any number likely to be nearest the average (M_{approx}) add together, regarding signs, the deviations (d) from it of all the numbers ; divide this result by the number of the measures the average of which you are obtaining (n) ; add the quotient to the chosen number."

$$M_{act} = M_{approx} + \frac{\Sigma d\,(\text{algebraic})}{n}$$

Thus, in column (3) of Table 12 are given the deviations of heights from M_{approx}, which, in this case, was chosen as 59. The algebraic sum of the deviations is 63·25 (−35·25 + 98·5),

hence $$M_{act} = 59 + \frac{63{\cdot}25}{50} = 59 + 1{\cdot}26 = 60{\cdot}26.$$

The weighted arithmetical mean, the third method of calculating the average, is serviceable as a short cut in dealing with a large number of measures. The formula is the following :

$$M = \frac{\Sigma\,(m.f.)}{n}$$

where m = measure of a limited group.
f = frequency of measure of limited group.
n = number of cases.

In finding the weighted arithmetical mean of the heights of the 50 boys, take measures 53, 55 and 57 as measures of the limited group. There are thus 2 cases at 53, 1 case at 55, 6 cases at 57, 15 cases at 59, etc., hence

$$M = \frac{(53 \times 2) + (55 \times 1) + (6 \times 57) \cdots (3 \times 67) + (1 \times 69)}{50}$$

$$= 60{\cdot}4.$$

The method of the guessed average is the quickest of the three. Moreover, it has the special advantage of calculating the average deviation (see below) at the same time.

The *median* is the measure above and below which an equal number of the individual measures lie. Thus, a perpendicular erected at the median bisects the surface of frequency. The median is the $\frac{n+1}{2}$th measure.

The simplicity of calculation of the median and its unambiguity makes it the most desirable central tendency to use in statistical investigations.[1]

The method of calculating the median is to take a table of frequencies (*e.g.* Table 13) and to count in from either end of the frequencies until half way (25 in this case) is almost reached; 24 brings us, counting in from the lower end, to the end of the measure (59·75). It will thus be seen that the median falls in the group "4 at 60." Since, however, 60 means from 59·875 to 60·125 we must find out how far into this group we must go before the 25th case is reached. Obviously we have to go $\frac{1}{4}$ of the distance between 59·875 and 60·125, *i.e.* ·0625. The median is thus ·0625 past the end of the 59·875 measure, or is at the point 59·875 + ·0625 = 59·9375.

The *mode* is the most common of the individual measures. In the table of heights the mode is not well defined. It may be said to lie between 58 and 58·5.

In normal distributions, the mode, median and average coincide.

MEASURES OF VARIABILITY.

There are three measures of variability in common use—the average deviation, the standard deviation, and the probable error.

The average deviation or *mean variation* (A.D. or m.v.) is the average (arithmetical) of the deviations (d) of the individual measures (m) from their average (M).

$$\text{A.D. or m.v.} = \frac{\Sigma(M - m)}{n}$$

$$= \frac{\Sigma d}{n}.$$

---

[1] The median is not so greatly affected by extreme measures as is the average. An average income of £200 per year of ten men may mean that one has £2,000 per year and the remaining nine nothing. The Hindoos have a proverb which states that "the cow was drowned in water of average depth up to the hoofs." The sportsman who shot a yard to the right of the duck with the right barrel, and a yard to the left with the left barrel, shot the duck on the average, but nevertheless it flew away and escaped.

Between M – A.D. and M + A.D. are 57·6 of the cases if the distribution is symmetrical and the observations sufficiently numerous.

In the case of heights, the sum of the deviations from the guessed average (this is approximately equal to the sum of the deviations from the actual or true average) was 98·5+ 35·25 or 133·75,

hence $$\text{A.D.} = \frac{133{\cdot}75}{50} = 2{\cdot}675$$

The wider the distribution the greater is the A.D. or other measure of variability.

The *standard deviation* or *error of mean square* (S.D. or σ) is the square root of the average of the squares of the individual deviations from their central tendency (usually M is used).

$$\text{S.D. or } \sigma = \sqrt{\frac{\Sigma d^2}{n}}.$$

The S.D. of a given series is somewhat larger than its A.D. Theoretically, and practically also if the distribution is symmetrical and the observations sufficiently numerous, the relation is constant at

$$\sigma = \sqrt{\frac{\pi}{2}}\,\text{A.D.} = 1{\cdot}25331\ \text{A.D.}$$

and conversely $$\text{A.D.} = {\cdot}7979\ \sigma.$$

Between M – σ and M + σ are 68·2 % of the cases.

Column (4) of Table 12 gives the squares of the individual deviations.[1] The sum of these is 644·77. Hence

$$\sigma = \sqrt{\frac{644{\cdot}7}{50}}$$
$$= \sqrt{12{\cdot}894}$$
$$= 3{\cdot}59$$

(σ calculated from formula σ = 1·25331 A.D. is 3·55).

The *probable error* (P.E.) of a distribution is the amount of difference from the average (or other central tendency) such that 50% of all the individual measures lie between M – P.E. and M + P.E. In other words, the P.E. is a value such that the number of measures that exceed it is the same as the number of measures that fail to reach it. For a normal distribution

---

[1] The squares of all integer numbers up to 10,000 are given in "Barlow's Tables."

$$\begin{aligned} \text{P.E.} &= \cdot 6745\ \sigma \\ \sigma &= 1\cdot 4825\ \text{P.E.} \\ \text{P.E.} &= \cdot 8453\ \text{A.D.} \\ \text{A.D.} &= 1\cdot 1843\ \text{P.E.} \end{aligned}$$

There are many methods of calculating the P.E. Probably the simplest method is to take the 25 and 75 percentiles (these are found in exactly the same way as the median, only 25 and 75 are taken instead of the 50 per cent.) and divide the difference between them by two. Hence

$$\text{P.E.} = \frac{75 \text{ percentile} - 25 \text{ percentile}}{2}.$$

In the case of heights in Table 12.

$$\begin{aligned} \text{P.E.} &= \frac{61\cdot 75 - 57\cdot 80}{2} \\ &= \frac{3\cdot 95}{2} \\ &= 1\cdot 975. \end{aligned}$$

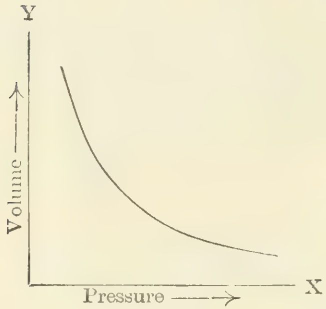
CORRELATION.

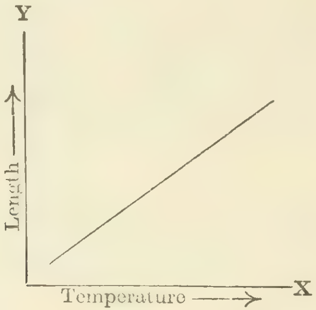
Up to the present we have been dealing with the distributions of single traits. It is often found, however, that traits, both mental and physical, tend to vary together. For example, we know that there is a tendency for weight to vary with height. But the relationship is not perfect, or we should always find that the tallest man was the heaviest, the shortest man the lightest, and so forth. This tendency towards concomitant variation, or the tendency of two or more traits to vary together, is called a correlation. A correlation coefficient is a measure of this tendency. This section will deal with the methods of finding correlations, *i.e.* of finding how far the variates in one series vary concurrently with those of another.

In the realm of physics the relationships are easy to determine, because they are constant. The physicist knows that the relationship between the pressure and volume of a gas is constant, and may be expressed by the formula :

$$P \times V = \text{a constant.}$$

The variation of the length of a metal rod with temperature is also constant. If measures of volume and pressure, or of length and temperature, are plotted along axes of X and Y, we get figures such as the following :





In the first case the graphical representation of the facts is a curve ; in the second, a straight line. Deviations of experimental measures from the smooth curve or the straight line would be looked upon, and rightly so, as errors of observation.

But in the case of all mental measures the relationship is never, or almost never, the same—it is variable. Hence the difficulty of measurement arises. Some of the difficulties that must be overcome are :

(*a*) The difficulty of an undistributed zero. This is overcome by using the deviations from the central tendencies of the distributions instead of the crude measures of the two traits.

(*b*) The difficulty of the form of distribution. In general, measures of mental traits approximate the normal distribution, and hence most measures of relationships assume that such is the case. (The Pearson coefficient assumes normal distributions ; the Spearman method of ranks, however, assumes that the distribution is rectangular.)

(*c*) The difficulty of the form of the relationship. The Pearson coefficient, r, assumes that the relationship is rectilinear, *i.e.* like the length-temperature of metal bar; the correlation ratio, η, measures the correlation correctly, even if it is non-rectilinear or skew.

The following are the more important methods of finding correlations:

1. The Pearson or Product-Moments Method (r).
2. The Spearman Foot-Rule or R Method.
3. The Method of Unlike Signs.
4. The Correlation Ratio Method (η).
5. The Median or Mid-ratio Method.

1. *The Pearson Coefficient of Correlation* (r) is of historical interest, because it was the first mathematically accurate method found of dealing with the problem. The method of calculating it is long and tedious. Its value ranges from +1·00 to −1·00. A correlation of +1·00 would mean that the two series varied from the central tendencies in exact proportions; a correlation of −1·00 would mean that the two series varied from the central tendencies in inverse proportions, *i.e.* in the case under consideration the lightest boy would always be the tallest, the heaviest the shortest, and so on; a zero correlation would mean that there was no causal connection between the two series, that one trait had no influence upon the other.

The formula given originally by Pearson is:

$$r = \frac{\Sigma x \, . \, y}{n \, . \, \sigma_1 \, . \, \sigma_2}$$

where x = the deviations in the first series,
y = the corresponding deviation in the second series,
n = the number of measures,
σ_1 = standard deviation of the first series,
σ_2 = standard deviation of the second series,

since $$\sigma_1 = \sqrt{\frac{\Sigma x^2}{n}} \text{ and } \sigma_2 = \sqrt{\frac{\Sigma y^2}{n}}$$

the formula may be written:

$$r = \frac{\Sigma x \, . \, y}{\sqrt{\Sigma x^2 \, . \, \Sigma y^2}}.$$

The second form is the easier one to use. A good arrangement of the columns in the calculation is shown in Table 12.

The squares of x (or d_1) and y (or d_2) may be read direct from Barlow's *Tables*, while Crelle's *Rechentafeln* or a slide rule may be used to find the products of x and y. A Pearson coefficient of such an example as the one under consideration, can be worked by a fairly proficient worker in about an hour and a quarter. The final part of the calculation, the labour of which could be reduced by using approximations, is as follows :

$$
\begin{aligned}
r &= \frac{\Sigma x \,.\, y}{\sqrt{\Sigma x^2 \,.\, \Sigma y^2}} \\
&= \frac{1630{\cdot}49}{\sqrt{644{\cdot}77 \times 14642{\cdot}06}} \\
&= \frac{1630{\cdot}49}{3073} \\
&= {\cdot}53.
\end{aligned}
$$

2. *Spearman's Foot-Rule or R Method* of finding correlation depends on comparison of the ranks (grading) in the two series. The formula given is :

$$R = 1 - \frac{\Sigma g}{c}$$

where g is the numerical gain in the rank of an individual in the second as compared with the first series, and c is the mean value of Σg by mere chance. For c, Spearman uses the formula

$$c = \frac{n^2 - 1}{6}$$

where n = the number of cases. When this value of c is substituted in the original formula [1] we get

$$R = 1 - \frac{6 \,.\, \Sigma g}{n^2 - 1}.$$

In the example (Table 12) the 10th individual in height is 4th with respect to weight. The gain is thus 6 places.

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[1] Pearson's Modification is

$$\rho = 1 - \frac{6\ \Sigma d^2}{n\,(n^2 - 1)}.$$

Only gains are recorded, and these are set down in column (9). The total gain is 150.

Hence,
$$R = 1 - \frac{6 \times 150}{50^2 - 1}$$
$$= 1 - \frac{900}{2499}$$
$$= 1 - \cdot 36$$
$$= \cdot 64.$$

The Spearman coefficient (R) bears a direct relationship to the Pearson coefficient (r), which enables the worker to convert the results obtained by the Foot-Rule Method into those which would have been obtained by the Product-Moments Method. Spearman's Conversion Table is given below:

TABLE 14.—Spearman Conversion Table.

R	r	R	r	R	r	R	r	R	r
·00	·00	·20	·31	·40	·59	·60	·81	·80	·95
·01	·01	·21	·32	·41	·60	·61	·82	·81	·96
·02	·03	·22	·34	·42	·61	·62	·83	·82	·96
·03	·05	·23	·35	·43	·62	·63	·84	·83	·96
·04	·06	·24	·37	·44	·64	·64	·84	·84	·97
·05	·07	·25	·38	·45	·65	·65	·85	·85	·97
·06	·08	·26	·40	·46	·66	·66	·86	·86	·98
·07	·11	·27	·41	·47	·67	·67	87	·87	·98
·08	·13	·28	·43	·48	·69	·68	·88	·88	·98
·09	·14	·29	·44	·49	·70	·69	·88	·89	·99
·10	·16	·30	·45	·50	·71	·70	·89	·90	·99
·11	·17	·31	·47	·51	·72	·71	·90	·91	·99
·12	·19	·32	·48	·52	·73	·72	·90	·92	·99
·13	·20	·33	·50	·53	·74	·73	·91	·93	·99
·14	·22	·34	·51	·54	·75	·74	·92	·94	1·00
·15	·23	·35	·52	·55	·76	·75	·93	·95	1·00
·16	·25	·36	·54	·56	·77	·76	·93	·96	1·00
·17	·26	·37	·55	·57	·78	·77	·94	·97	1 00
·18	·28	·38	56	·58	79	·78	·94	·98	1·00
·19	·29	·39	·57	·59	·80	·79	·95	·99	1·00

Serious objection has been taken to the Spearman formula by Pearson and Brown because it assumes the rectangular distribution, a form of distribution never, or but rarely, met with in practice.

3. *The Method of Unlike Signs.*—The formula for this method is

$$r = \cos \pi \frac{U}{100}$$

where U = the percentage of unlike signs in the deviations of the two series, and $\pi = 180$.[1] $\cos \pi$ is constant, hence

---

[1] This formula may be derived from Yule's formula for correlation of presence and absence.

$$r = \frac{ad + bc}{ad - bc}$$

where a = number of cases in which both traits are present.
b = number of cases in which first trait is present and second absent.
c = number of cases in which second trait is present and first absent.
d = number of cases in which both traits are absent.

The above formula may be modified thus:

$$r = \sin \left(\frac{\pi}{2} \frac{\sqrt{ad} - \sqrt{bc}}{\sqrt{ad} + \sqrt{bc}} \right).$$

Since

$$\sin A = \cos \left(\frac{\pi}{2} - A \right),$$

$$r = \cos \left[\frac{\pi}{2} - \frac{\pi}{2} \frac{\sqrt{ad} - \sqrt{bc}}{\sqrt{ad} + \sqrt{bc}} \right]$$

$$= \cos \frac{\pi}{2} \left(1 - \frac{\sqrt{ad} - \sqrt{bc}}{\sqrt{ad} + \sqrt{bc}} \right)$$

$$= \cos \frac{\pi}{2} \left(\frac{2\sqrt{bc}}{\sqrt{ad} + \sqrt{bc}} \right)$$

$$= \cos \pi \frac{\sqrt{bc}}{\sqrt{ad} + \sqrt{bc}},$$

and by practically substituting the arithmetical for the geometrical mean we get

$$r = \cos \pi \frac{U}{L + U}$$

where U = % of unlike signs.,
L = % of like signs,
and since L + U = 100,

$$r = \cos \pi \frac{U}{100}.$$

a table giving r for the various percentages of U may be constructed. Such a table is given below :

TABLE 15.—Table for Cos π U Correlation.

If U is greater than 50, first subtract it from 100, then prefix the minus sign to correlation indicated.

% U	R	% U	R	% U	R
0	1·0000	17	·8602	34	·4819
1	·9996	18	·8439	35	4542
2	·9982	19	·8268	36	·4260
3	·9953	20	·8089	37	·3973
4	·9924	21	·7902	38	·3682
5	·9880	22	·7707	39	·3387
6	·9826	23	·7504	40	·3089
7	·9762	24	·7293	41	·2738
8	·9688	25	·7074	42	·2485
9	·9604	26	·6848	43	·2180
10	·9510	27	·6615	44	·1873
11	·9407	28	·6375	45	·1564
12	·9295	29	·6129	46	·1253
13	·9174	30	·5877	47	·0941
14	·9044	31	·5620	48	·0628
15	·8905	32	·5358	49	·0314
16	·8757	33	·5091	50	·0000

In the example, the unlike signed pairs of columns (3) and (6) of Table 12, number 17. This makes 34% which corresponds to r = ·4819.

4. *The Correlation Ratio Method* (η).—The correlation ratio (η) is defined as the ratio of the standard deviation of the means of the arrays (Σ) to the total standard deviation (σ).

$$\eta = \frac{\Sigma}{\sigma}.$$

The following example (slightly modified) taken from Brown, *Mental Measurement* (p. 136) will illustrate the method of calculation.

TABLE 16.—86 Boys, aged 11-12 years.

Correlation between speed and accuracy in the addition of groups of 10 single digits. Two tests of five minutes' duration each.

Speed of addition (x) →

Accuracy of addition (y) ↓	1	2	3	4	5	6	7	8	Totals (N y)
0–4	—	3	·5	·5	1	—	—	1	6
5	1	1	1	1	—	—	—	—	4
6	—	2	·5	·5	—	—	—	—	3
7	·5	2·5	1	1·5	1·5	2	—	—	9
8	—	3	2	4	5	3	—	1	18
9	1	4·5	4·5	5·5	5·5	3	·5	·5	25
10	1	2·5	5	5	2·5	2·5	2	·5	21
Totals (N x)	3·5	18·5	14·5	18	15·5	10·5	2·5	3	86
Means of Arrays	8·3	7·5	8·9	8·8	8·7	8·5	10·3	6·7	

It is rather unfortunate that a boy has been divided between two scores, but the table is almost self-explanatory. Thus, a boy scoring 4 for speed obtains 5 for accuracy; 3 boys obtaining 6 for speed score 8 for accuracy, and so forth. A vertical or horizontal column is known as an array. The means of the vertical arrays are 8·3, 7·5, 8·9, etc. If these are arranged in order of merit the S.D. may be easily calculated, as is shown below :

Frequency.	Derivations (d) from guessed average of 8·5.	n × d^2
3 cases at 6·7	− 1·8	9·72
18·5 ,, 7·5	− 1·	18·5
3·5 ,, 8·3	− ·2	·14
10·5 ,, 8·5		
15·5 ,, 8·7	+ ·2	·62
18· ,, 8·8	+ ·3	1·62
14·5 ,, 8·9	+ ·4	2·32
2·5 ,, 10·3	+ 1·8	8·1
	TOTAL, -	41·02

$$\Sigma = \sqrt{\frac{\Sigma d^2}{n}} = \sqrt{\frac{41\cdot02}{86}} = \cdot693.$$

The total standard deviation (σ) calculation is given below:

Frequency (n).	Deviation of y (d)	n × d^2.
6	− 5·5	181·5
4	− 3	36
3	− 2	12
9	− 1	9
18	0	—
25	+ 1	25
21	+ 2	84
86	Total, -	347·5

$$\sigma = \sqrt{\frac{\Sigma d^2}{n}} = \sqrt{\frac{347\cdot5}{86}} = 2\cdot01,$$

hence $$\eta = \frac{\Sigma}{\sigma} = \frac{\cdot693}{2\cdot01} = \cdot34:$$

5. *The Median or Mid-ratio Method.*—This fifth method of finding the correlation (Galton) between two distributions is heartily approved by Thorndike, both on account of its reliability and of its simplicity of calculation. The method is what it professes to be, namely, that of finding the mid-ratio of the $\frac{x}{y}$ and the $\frac{y}{x}$ ratios. Let us take the following

example from Thorndike's *Empirical Studies in the Theory of Measurement*, where these paired values for x and y are given :

x	y	x	y	x	y
−7	5	−1	−3	+1	+7
−5	−5	−1	−1	+3	−1
−5	−3	−1	+1	+3	+1
−5	−1	−1	+1	+3	+1
−3	−7	−1	+3	+3	+3
−3	−3	+1	−3	+3	+5
−3	−3	+1	−1	+5	−1
−3	−1	+1	+1	+5	+3
−3	+1	+1	+3	+5	+3
−1	−5	+1	+5	+7	+5

The directions for calculation as given by Thorndike are : "First, one makes an exact median sectioning of the x's and the y's and then counts the cases that give negative ratios. By inspection one then chooses for the $\frac{y}{x}$ ratios an approximate median (say $\frac{1}{3}$), and for convenience draws a line to include these cases and counts them. One then increases their number by adding the cases of the next smallest ratios not included, or by taking away the cases of the largest ratios included until one reaches the Median ratio. One then repeats the process of guessing at an approximate median for the $\frac{x}{y}$ ratios and correcting it." A sample calculation of the above is given below :

x ⟶

	−7	−5	−3	−1	+1	+3	+5	+7
y −7			1					
−5	1	1		1				
−3		1	2	1	1			
−1		1	1	1	1	1	1	
↓ +1			1	2	1	2		
+3				1	1	1	2	
+5					1	1		1
+7					1			

$N = 30$	$\frac{1}{2}N = 15$
negative $(< o)$ 8	negative 8
$\frac{y}{x}$	$\frac{x}{y}$
$\not< \frac{1}{3} = 4$	$\not< \frac{1}{3} = 5$
$\frac{3}{5} = 3$	$\frac{3}{5} = 2$
hence, Median $\frac{y}{x} = \frac{3}{5}$	Median $\frac{x}{y} = \frac{3}{5}$

$$\therefore \text{ Median Ratio} = \cdot 6.$$

Fig. 7.—Median Ratio Table.

The above examples give illustrations of the calculation of the three things—central tendencies, variabilities, and correlations—which occur most frequently in mental measurements. But the maxim "learn by doing" has peculiar applicability to statistical treatment of measurements, hence the reader is strongly advised to make simple calculations of the type shown. He is also recommended to make a careful study of two or three typical investigations along these lines. The study of Thorndike on "Handwriting,"[1] in which a measuring stick or scale for children's handwriting is made, and Cattell's "A Statistical Study of American Men of Science,"[2] can both be confidently recommended for the purpose.

References: Bowley: *An Elementary Manual of Statistics.* Bowley: *Elements of Statistics.* Brown: *The Essentials of Mental Measurement.* Elderton: *Primer of Statistics.* King: *The Elements of Statistical Method.* Myers: *Text Book of Experimental Psychology*; Chap. X. Thorndike: *Educational Psychology*; 2nd Ed. Chaps. II., VIII.-X. and appendix III. Thorndike: *Mental and Social Measurements*; 2nd Ed. Whipple: *Manual of Mental and Physical Tests*; Chaps. I., II. and III. Yule: *An Introduction to the Theory of Statistics.*

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[1] *Teachers' College Record,* Vol. XI., No. 2.

[2] *Science, New Series,* Vol. XXIV., Nos. 621, 622, 623.

CHAPTER IV.

MEDICAL INSPECTION OR HEALTH EXAMINATION.

THERE is undoubtedly a close connection between physical well-being and mental progress. We cannot expect a child suffering from disease and physical defects to make normal progress in his mental development. Medical Inspection or Health Examination of school children endeavours to discover these defects and to reduce their influence to a minimum. The subject, however, has assumed such great importance in recent years that only a few of the more important points can be dealt with in a single chapter. Detailed knowledge, especially with respect to the symptoms and the duration of diseases, must be obtained either from medical treatises or from books dealing with medical inspection and school hygiene. Of the latter type, the books in the list given in the footnote[1] can be confidently recommended.

Types of Medical Inspection. Medical Inspection, as carried on at the present time in English schools, falls fairly sharply into two divisions. The first type is the medical inspection as carried out under the regulations of the Board of Education, where the scholars, for the most part, are only examined two or three times during their school career—at entrance and on leaving—with perhaps an extra examination when the scholars reach the age of ten or thereabouts. The second type is found where the medical officer is definitely attached to a school and visits it regularly either daily or weekly. This second type is by far the more effective and beneficial and it is to be hoped that the first—the compulsory type—will supersede it in course of time. With the multiplication of school medical officers and school nurses, far more attention is now being devoted to the problem than was conceived to be possible half-a-dozen years ago.

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[1] Porter, Charles : *School Hygiene and the Laws of Health* ; London, 1906.

Lyster, Robert A. : *School Hygiene* ; London, 1908.

Mackenzie, W. Leslie : *The Medical Inspection of School Children* : Edinburgh, 1904.

Hogarth, A. H. : *Medical Inspection of Schools* Oxford, 1909.

Laurie, A. P. (Ed.) : *The Teacher's Encyclopaedia* ; Vol. IV.

History. Health examinations of an elementary nature have been made by teachers and parents throughout the ages, and not a few educators have placed the health of the scholar in the forefront of their theory and practice. But medical inspection as we know it to-day is a development of the last thirty years. France, Germany, Switzerland, and the Scandinavian countries, until recently were all ahead of England. Such progress, however, has been made in England during the past five years that she now bids fair to lead the world. The awakening came at the time of the Boer War, when more than half the persons applying for enlistment had to be refused on grounds of physical defect. In 1904 appeared the three-volume *Report of the Interdepartmental Committee on Physical Deterioration.* One of its recommendations was the systematic inspection of school children by medical men. This was followed by a second interdepartmental committee (1905) which had for its reference : "(*a*) to ascertain and report on what is now being done, and with what result, in respect of medical inspection of children in elementary schools, and (*b*) to inquire into the existing arrangements of voluntary agencies for provision of meals to school children, and to report as to the possibility of its better organisation."

Their report[1] was issued in the same year, and so unsatisfactory was the condition of affairs which it showed, that its recommendations were immediately acted upon. Birrell's Bill of 1906, which failed to become law, contained a medical inspection clause. The difficulty was overcome by introducing a similar clause in the non-contentious Education (Administrative Provisions) Act of 1907. The clause dealing with medical inspection is as follows :

"The duty to provide for the medical inspection of children immediately before or at the time of, or as soon as possible after, their admission to a public elementary school, and on such occasions as the Board of Education direct, and the power to make arrangements as may be sanctioned by the Board of Education for attending to the health and physical condition of the children educated in public elementary schools."

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[1] *The Report of the Interdepartmental Committee on Medical Inspection and Feeding of School Children attending Public Elementary Schools.* Wymans, Vols. I. and II., 1905.

To prevent defection, the "Code" for the following year threatened the withdrawal of grants from those authorities which did not set up the machinery of medical inspection. Explanatory Circulars[1] have facilitated the introduction of inspection and in less than five years it has become complete for England and Wales. Two financial drawbacks hinder the efficiency of the scheme, viz.: (1) the refusal to reintroduce the "epidemic grants" which were withdrawn in 1903; and (2) the tardiness in giving an additional grant from the exchequer for the work of medical inspection. The former is prejudicial in two ways, for it not only makes Local Education Authorities hesitant about the closing of schools when infectious diseases are rife, but it also penalises all head teachers whose salaries are dependent upon the average attendances of their scholars.

Need for Health Examinations. That medical inspection was not made compulsory too soon is shown by the reports of the medical officers engaged in the work. The Chief

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[1] *Circular* 576. Memorandum on Medical Inspection of Children in Public Elementary Schools, 1907.

Circular 582. Circular to Local Education Authorities. Schedule of Medical Inspection, 1908.

Circular 596. Circular to Local Education Authorities under Part III. of the Education Act, 1902, on certain questions arising under section xiii. of the Education (Administrative Provisions) Act, 1907, and the Code of Regulations for Public Elementary Schools, 1908, viz.: (*a*) The functions of the "School Medical Officer": (*b*) Provision for Medical Inspection of School Children under the Code of 1908; (*c*) The Local Education Authority's Annual Report on Medical Inspection to the Board of Education; and (*d*) Arrangements for attending to the Health and Physical Condition of School Children, 1908.

Circular 728. Provision for Medical Inspection for the Year ending 31st July, 1910, 1909.

Circular 792. Grants for Medical Treatment of children attending Public Elementary Schools, April 9th, 1912. Enclosing a copy of "Regulations under which Grants in respect of medical treatment and care of children attending Public Elementary Schools and certain Special Schools in England and Wales will be made by the Board of Education during the year ending March 31st, 1913."

Medical Officer of the Board of Education makes the following statement (p. 27) in his Report for 1909 :

> "It may, however, be generally stated that, in respect to the six million children in the Public Elementary Schools of England and Wales, about 10 per cent. of them suffer from serious defect in vision, from 3 to 5 per cent. suffer from defective hearing, 1 to 3 per cent. have suppurating ears, 8 per cent. have adenoids, or enlarged tonsils, of sufficient degree to obstruct the nose or throat and to require surgical treatment, 20 to 40 per cent. suffer from extensive and injurious decay of the teeth, 40 per cent. have unclean heads, about 1 per cent. suffer from ringworm, 1 per cent. are affected with tuberculosis of readily recognisable form, and ½ to 2 per cent. are afflicted with heart disease. It is to be feared that in the aggregate this formidable category of disease and defect means a large degree of suffering, incapacity, and inefficiency."

Objects of Medical Inspection. Wood [1] says that health examinations of school children have two purposes :

1. "To detect, at as early a stage as possible, cases of infectious and contagious disease, so that by exclusion and isolation, the rest of the pupils and the community may be protected.

2. To discover physical defects and chronic ailments of importance, in order that the limitations of the pupil may be understood and that curable defects and disorders may receive appropriate attention."

To these must be added a third, namely :

3. To amass a body of information, statistical and otherwise, which shall be a true guide to further preventive measures and legislation.

So far as England and Wales are concerned, purpose 1 and to some extent purpose 2 have been inadequately fulfilled owing to the long periods between the visits of the medical officer and to the paucity of available centres for medical treatment and school clinics. Purpose 3 has been carried out, but the present expenditure on medical inspection, estimated at about £300,000, is far too great if statistics are to be the only results.

Persons involved in Medical Inspection. The people concerned with medical inspection are : (*a*) the School Doctor ; (*b*) the School Nurse ; (*c*) the Teacher, especially the Head-Teacher; (*d*) the parents and the scholars; (*e*) the Care (or Health) Committee; and (*f*) School Attendance Officers.

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[1] Wood : *Health and Education* ; p. 13, University of Chicago Press, 1910.

(*a*) The School Doctor is the ultimate authority on all questions concerning the health of the scholars. He must see that the sanitary arrangements of the school are satisfactory. (Unfortunately he has little power to alter bad lighting and bad ventilation in schools because the buildings are erected before he inspects them. Far too often, badly planned schools and furniture are the cause of defects of the eyes and of the skeleton, and these defects it is the doctor's duty to detect.) He must examine all the children medically, although much help may be obtained, especially in the selection of special cases, from the nurse and the teacher. The responsibility for diagnosis rests with him and must never be delegated. If the teacher and nurse render assistance he must exercise supervision and control over them with respect to this branch of their work. He is responsible for the individual records of the children and for the Annual Report sent up to the Board of Education. If no dental surgeon is employed he must also examine the teeth of the scholars. The onus of excluding scholars on the grounds of health or of closing a school during an epidemic of disease rests on him. As he is often the Medical Officer of Health, this particular duty occasions but little trouble. He must, so far as he is able, train the teachers and nurses and, incidentally, the parents of the scholars in matters relating to inspection and to preventive measures. But he is not expected to cure—he diagnoses and recommends treatment. Treatment is reserved for hospitals and clinics and private practitioners.

The qualifications of a school doctor are thus very exacting. He must understand children, must be quick at diagnosis, and must be enthusiastic and original. The experience gained at a general hospital, at a children's hospital, at hospitals for diseases of the ear and of the eye, and at a fever hospital is not too wide for the task. He should possess the degree of D.P.H. and above all, he must be devoted to the cause of prevention of illness. A knowledge of Education and Psychology would also be of great assistance to him.

(*b*) The School Nurse occupies an intermediary position between the school and the home. At the school she may give assistance in the examinations and attend to the treatment of minor injuries. Visiting the school far more frequently than the doctor, she is often able to detect early signs of ill-health, and to refer these cases to him for diagnosis. She can also give demonstrations on the care of the teeth, of cleansing of heads and of care of infants to the children in the school. These lessons can also be taught to the mothers in the home. It is the duty of the nurse to see that the treatment recommended by the medical officer is carried out. She assists the doctor in his routine examinations and " follows up " the special cases to see that the cure is complete. Her duties are thus more those of a special administrative officer than of a nurse in the general acceptance of the word. If she is wise, she enlists the sympathy and co-operation of the school attendance officer. Nurses should be from five to ten times as numerous as school doctors.

(*c*) The functions of the teacher, who comes into such close and frequent contact with the scholars, are most important. Although it is not his province to diagnose cases, he may bring to the attention of the medical officer and the nurse all cases of chronic and croupy coughs ; sore throats ; neck swellings ; flushings of the face ; skin eruptions; colds in the head, with running eyes and nose ; general emaciation and lassitude ; physical defects like lameness, and spinal curvatures ; mal-nutrition ; constant headaches ; cases of pediculosis ; pallor ; puffiness of face and eyes ; shortness of breath ; sore eyes, squint and defective vision ; suppurating ears and deafness ; abnormal twitchings and other evidences of defective nervous organisation.

He may also test the eyesight and the hearing of his pupils. The former is usually done by means of a Snellen's Test Card, which has on it letters of various sizes, visible by normal people at 60, 36, 24, 18, 12, 9, 6, 4·5 and 3 metres respectively. The card is usually placed at a distance of six metres (20 ft.) from the pupil and in a good light. Each eye is tested separately ; the one not being tested is covered with a card and not by the hand. The scholar is asked to read the letters, and the last line read correctly (to within 10 per cent.) is noted. If scholars are too young to read, cards with E's turned in different directions may be substituted. The scholar in this case indicates which way the E's point. The record is made as a vulgar fraction the numerator of which is the distance, in metres, of the chart from the eye ; and the denominator the number of the last line read. A record $\frac{6}{6}$ would show a normal eye ; $\frac{6}{36}$ would mean that a child read, at a distance of 6 metres, the line marked as 36 metres for the normal eye. In no case must the teacher attempt to say whether a defect is due to hypermetropia (long sight) myopia (short sight) or astigmatism ; the defect must be brought to the notice of the medical officer.

Hearing is best tested by the tick of a watch, if a special room is available for the purpose. The pupil does not face the watch, but sits on a chair sideways with one ear plugged with cotton wool or a finger. The teacher then finds if a watch can be heard at a distance from which normal people hear it. This distance is marked off previously in the quiet room which is reserved for this test. The distance at which the watch is heard distinctly is recorded as the numerator of a fraction, of which the normal distance is the denominator. The best practical test is that of the whispered voice, which ought to be heard at a distance of 18 ft. The whisper is made with the traces of air left at the end of an exhalation. A little practice makes a teacher quite competent to detect the bad cases. The records in this second case are simply those of " heard " or " not heard." Scholars found to be defective in hearing should be placed in the front of the class, and those defective in eyesight should be provided with spectacles.

(*d*) The parents ought to be invited to attend the examination of their children. Advice as to treatment can then be given by the medical officer.

(*e*) The work of the Care (or Health) Committee is to support the School Nurse and teachers in their endeavours to secure the cleanliness and the physical welfare of the children. The members of the committee ought to be prepared to visit the homes of the children and to assist in every possible manner in securing a healthy environment for them.

Common Diseases and Defects. The commoner diseases and defects found in school children are :

1. Diseases of Posture :
    - *a.* Round shoulders (often caused by Myopia).
    - *b.* Curved spine (often caused or exaggerated by badly fitting desks).
    - *c.* Flat foot.

2. Diseases of Nutrition:
   - *a.* Rickets (a disease of childhood leaving permanent defects).
   - *b.* Debility.
   - *c.* Anaemia.

3. Diseases of the organs of digestion:
   - *a.* Carious teeth.
   - *b.* Indigestion.
   - *c.* Constipation.
   - *d.* Diarrhœa.
   - *e.* Intestinal worms.
   - *f.* Appendicitis.

4. Diseases of the bones and joints:
   - *a.* Periostitis.
   - *b.* Tuberculosis.

5. Diseases of the Lymphatic System:
   - *a.* Enlarged Glands.

6. Circulatory System:
   - *a.* Defective circulation (shown by blue extremities).
   - *b.* Heart strain (often due to overstrain in Athletics).
   - *c.* Heart Disease (often a result of rheumatism and rheumatic fever).

7. Diseases affecting Respiration:
   - *a.* Nasal obstruction.
   - *b.* Cold in the head (may be due to a fever).
   - *c.* Adenoids (a frequent cause of deafness).
   - *d.* Enlarged Tonsils.
   - *e.* Various lung diseases, including consumption.

8. Diseases of the skin:
   - I. Those caused by Animal Parasites, and contagious:
     - *a.* Pediculosis (lice).
     - *b.* Scabies (itch).
   - II. Those caused by Vegetable Parasites, and contagious:
     - *a.* Ringworm.
     - *b.* Favus.
   - III. Those caused by Microbes, and contagious:
     - *a.* Impetigo (scabs).
   - IV. Non-contagious diseases:
     - *a.* Eczema.
     - *b.* Nettle-rash.
     - *c.* Warts.
     - *b.* Chilblains (often associated with defective circulation).

9. Defects of Sight and Eyes :
   - *a.* Myopia (short sight : concave lenses).
   - *b.* Hypermetropia (long sight : convex lenses).
   - *c.* Astigmatism (irregular sight : cylindrical lenses).
   - *d.* Trachoma (granular eyelids).
   - *e.* Conjunctivitis (disease of the conjunctiva).
   - *f.* Squint.
   - *g.* Ulcers of the cornea.
10. Defects of the Ear and Hearing :
    - *a.* Deafness (caused by cerumen (wax), punctured eardrum, inflammation of the middle ear, blocking of eustachian tube, etc.).
11. Diseases of the Nervous System :
    - *a.* Habit spasm or Tic (usually as facial contortions).
    - *b.* Chorea (St. Vitus Dance).
    - *c.* Epilepsy (Falling sickness).
    - *d.* Hysteria.
    - *e.* Headache (not a disease but a valuable symptom of disorder).
    - *f.* Nervousness and neurotic tendencies.
12. Fevers (tending to be epidemic) :
    - *a.* Measles.
    - *b.* German Measles.
    - *c.* Chicken Pox.
    - *d.* Scarlet Fever.
    - *e.* Whooping Cough.
    - *f.* Mumps.
    - *g.* Diphtheria.
    - *h.* Smallpox.

Of all the diseases and defects, probably malnutrition, tuberculosis, defective eyesight, defective hearing and dental caries are most injurious during the school life of children.

In 1909, 42,365 children of school age were examined for vision by the medical officers of Blackburn, Bolton, Brighton,[1] Cambridge, Cardiff, Edmonton, Gloucestershire, Lancashire, Salford,[1] and Southampton, and the following percentage results were obtained :

	$\frac{6}{6}$	$\frac{6}{9}$	$\frac{6}{12}$	$\frac{6}{18}$	$\frac{6}{24}$	$\frac{6}{36}$	$\frac{6}{60}$
Right, - -	69·5	14·3	6·4	4·4	2·3	1·8	1·3
Left, - -	68·5	14·7	6·5	4·3	2·3	1·4	1·3

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[1] With spectacles on.

The commonest eye defect in children is hypermetropia, in fact, the eyes of children below 9 years of age are usually hypermetropic. At 9 years of age the majority of eyes are emmetropic (normal). From 9 years onwards the eyesight tends to become increasingly myopic. This defect tends to correct itself between the ages of 40 and 50 owing to the flattening of the lens which normally takes place during that period (presbyopia). It is found that rural populations have better eyesight than urban ones, and suburban populations better than city ones.

About 4 per cent. of boys and 4 per cent. of girls are colour-blind (red-green), but this defect does not seriously handicap the school-work except, perhaps, the drawing and the nature-study. As 80 to 90 per cent. of all the things we know are learnt through the medium of vision, the importance of preserving it in as good a state as possible is seen to be great. No book should be used which does not satisfy Cohn's test.[1]

The British Association Committee on the Influence of School-books upon Eyesight recommended that the following minimum requirements with regard to type should be met by all school texts :

Age of Reader.	Minimum Height of Face of Short Letters.	Minimum Length of Alphabet of Small Letters.	Minimum Interlinear Space.	Maximum No. of Lines per 100 mm. or 4 inches.	Maximum Length or Measure of Line.
Under 7 years,	3·5 mm.	96 mm. or 272 pt.	6·5 mm. or 18 pt.	10	. .
7 to 8 years,	2·5 mm.	72 mm. or 204 pt.	4·0 mm. or 11 pt.	15	100 mm. or 4 in.
8 to 9 years,	2·0 mm.	55 mm. or 156 pt.	2·9 mm. or 8 pt.	20	93 mm. or $3\frac{2}{3}$ in.
9 to 12 years,	1·8 mm.	50 mm. or 143 pt.	2·4 mm. or 7 pt.	22	93 mm. or $3\frac{2}{3}$ in.
Over 12 years,	1·58 mm. or $\frac{1}{16}$ in.	48 mm. or 133 pt.	2·2 mm. or 6 pt.	24	93 mm. or $3\frac{2}{3}$ in.

1 inch = 25·4 mm. 1 point = $\frac{1}{72}$ inch = 0·353 mm.

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[1] This consists of a square hole of 1 cm. side cut in a piece of cardboard. When the bottom of the square is placed just above a line of print, not more than two lines should be visible within the square. Almost one half of school and college texts at the present time fail to pass this test.

Defective hearing is somewhat difficult to detect. If careful examinations are made, defects are found to exist in about 8 per cent. of the scholars. Many of these, of course, are temporary and disappear with the removal of the cause. In about 1 per cent. of cases the defect is permanent and of such a nature as to necessitate special provision being made for it. In congenital deafness the subjects are also mute and have to be taught lip-reading. It is certain that a great deal of the apparent stupidity of scholars is due to defective hearing.

So far as can be ascertained the English have the unenviable reputation of having the worst teeth of all the nations of the world. In comparatively superficial examinations by medical men the range[1] for "leavers" with sound teeth is found to lie between 2·3 and 38 per cent. in various districts of England. In fact, it may be taken as correct that 90 per cent. of school children have defective teeth and that more than half have four or more defective. If the examination is made by a dental surgeon, the number of children with sound teeth is found to diminish. In Cambridge, Gant found 2 per cent. sound, and 2 per cent. were also found in Kettering. The amount of suffering, general inefficiency, and actual bodily disease which these statistics represent is truly appalling. And it is nearly all preventable. Children ought to be made to eat hard food such as crusts, dry toast, and hard biscuits, and to be taught the use of the tooth-brush. It is a simple thing to tell children to brush the teeth with precipitated chalk every evening and to wash the mouth after meals, and this simple procedure would make a great difference in the dentition of the next generation. Since caries soon spreads from one tooth to another, the importance of dealing with it in its early stages is clear. The milk teeth are, in this respect, most important, for they tend, if carious, to infect the second set. The influence of the teacher ought to be freely exercised during the next twenty years for the purpose of getting better dental conditions among the elementary school children of the country.

Clinics. The law of England at the present time compels medical inspection but leaves treatment optional. Treatment in the out-patients department of a hospital is unsatisfactory because these institutions are already overcrowded, and consequently there is great waste of time in getting any treatment at all. Further, it is nobody's business to see that the cases are followed up. Especially is it difficult to secure dental treatment. To remedy these defects, about sixty (in 1912) of the more enlightened education authorities of England have instituted school clinics. The essential feature of a school clinic is that it provides treatment in addition to inspection. The minor ailments can be treated regularly, followed up, and prevented from becoming permanent defects. The more serious cases can be sent on to the hospitals. The school clinics prevent leakage between inspection and treatment. They insure a more regular attendance at school and in this way partly pay for themselves from the increased attendance grant of Government. They have been especially successful in the treatment of dental caries, ringworm and adenoids. Ringworm, in the better clinics, is now being treated by X-rays instead of by the old-fashioned drugs. The clinics are not expensive. A clinic of eight rooms with a whole-time medical officer, two nurses, a dental surgeon, and a caretaker can be established for £250 and run at an annual cost of £800 to £1,000. Such an institution is capable of giving treatment to many thousands of cases each year.

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[1] *Chief Report of Medical Officer*; 1910. Cd. 5925.

Records of Medical Inspection. The form of record prescribed by the Board of Education and printed below is an exceedingly good one, although it errs on the side of over-elaboration.

TABLE 17.

SCHEDULE OF MEDICAL INSPECTION.

I. Name____________ Date of Birth____________

Address____________ School____________

II. Personal History:

(*a*) Previous Illnesses of Child (before admission).

Measles.	Whooping Cough.	Chickenpox.	Scarlet Fever.	Diphtheria.	Other Illnesses.

(*b*) Family Medical History (if exceptional).

——	I.	II.	III.	IV.
1. Date of Inspection,				
2. Standard and Regularity of Attendance,				
3. Age of Child,				
4. Clothing and footgear,				
[III.—*General Conditions.*]				
5. Height,				
6. Weight,				
7. Nutrition,				
8. Cleanliness and condition of skin,				
Head,				
Body,				
[IV.—*Special Conditions.*]				
9. Teeth,				
10. Nose and throat,				
Tonsils,				
Adenoids,				
Submax. and cervical glands,				
11. External eye disease,				
12. Vision,				
R.				
L.				
13. Ear Disease,				
14. Hearing,				
15. Speech,				
16. Mental condition,				
[V.—*Disease or Deformity.*]				
17. Heart and circulation,				
18. Lungs,				
19. Nervous system,				
20. Tuberculosis,				
21. Rickets,				
22. Deformities, Spinal Disease, etc.,				
23. Infectious or contagious disease,				
24. Other disease or defect,				
Medical Officer's initials,				

General observations. Directions to Parent or Teacher.

A simpler form in use at the Fielden School, University of Manchester, where physical measurements are taken six times a year, where the medical officer attends one half-day per week and where the dentist is in regular attendance, is given below :

TABLE 18.

MEDICAL EXAMINATION OF SCHOOL CHILDREN.

....................*School.* *Record of*..................... *born*............ *in*..........

Date.	Height in inches.	Weight in pounds.	Vision and Eyes.			Hearing. Whispered Voice at 18 ft.		Heart.	Lungs.	Teeth. (Or see separate report.)	Nervous System and other Organs.	REMARKS. (1) Medical Officer. (2) Head Teacher.
			R.	L.	Notes.	R.	L.					

Measles................ Scarlet Fever.......... Diphtheria.......... SUMMARY—

Whooping Cough........ Mumps............... Chicken Pox........

Rheumatism................ Growing Pains.................

The form of the dental record is shown below :

TABLE 19.

Name (Surname first). . . . .

Date.	Teeth requiring Treatment.	Mastication.	Remarks.
	R ┼ L		
	┼		
	┼		
	┼		
	┼		
	┼		
	┼		
	┼		
	┼		

The forms of communication between the parents and the school are as follows :

TABLE 20.

Name....................

It will greatly help the school authorities in their care of the children if parents will kindly state whether the pupil has already had any of the following illnesses :

Measles ....Scarlet Fever ......Diphtheria ....
Mumps ....Whooping Cough....Rheumatism ....
Growing Pains.............. Chicken Pox...............

TABLE 21.

HEALTH CERTIFICATE.

(To be brought by each Pupil to the School at the commencement of the Term.)

I hereby declare that there has been no infectious or contagious illness in the house in which my $\left\{\begin{matrix}\text{son}\\ \text{daughter}\end{matrix}\right.$ (or ward) ....resides, or has been residing, for a period of.....................and that to my knowledge $\left\{\begin{matrix}\text{he}\\ \text{she}\end{matrix}\right.$ has not been in contact with anyone suffering from such illness. If any such illness should occur in the house from which the above Pupil attends School, I will at once inform the $\left\{\begin{matrix}\text{Senior Master.}\\ \text{Senior Mistress.}\end{matrix}\right.$

Signature of Parent or Guardian ....

Address ....

Date....................

N.B.—The quarantine period, or the period of isolation of children who have been exposed to infection, is, for

Diphtheria and Scarlet Fever - - -	14 days.
Measles and Whooping Cough - - - -	18 days.
Chicken Pox, Mumps, and German Measles -	21 days.

TABLE 22.

Dear Sir,

Your $\substack{\text{son}\\\text{daughter}}$ was examined on........... .... in accordance with the arrangements described in the Prospectus.

$\substack{\text{He}\\\text{She}}$ is reported to be in need of dental treatment, and we recommend that you take $\substack{\text{him}\\\text{her}}$ to see a dentist. The enclosed chart indicates the teeth requiring treatment, and should be handed to the dentist.

Please acknowledge the receipt of this note.

Yours faithfully,

Superintendent.

TABLE 23.

Name..

These records and report forms have proved extremely useful, and similar ones could probably be used with success in all secondary schools and in many suburban elementary schools.

References. Board of Education: *Annual Reports of the Chief Medical Officer of the Board of Education.* Gulick and Ayres: *Medical Inspection of Schools.* Hogarth: *Medical Inspection of Schools.* Kelynack: *Medical Examination of Schools and Scholars* (contains excellent Bibliographies). Laurie (Ed.): *The Teacher's Encyclopaedia*; Vol. IV. Lyster: *School Hygiene.* Mackenzie: *The Medical Inspection of School Children.* Porter: *School Hygiene and the Laws of Health.* *Report of Interdepartmental Committee*; 1905, *Medical Inspection and feeding of Children attending Public Elementary Schools* (Cd. 2779). Whelpton: *Physical Education.* Wood: *Health and Education.*

SECTION II.

THE PHYSIOLOGICAL BASIS OF MENTAL LIFE: PHYSIOLOGICAL PSYCHOLOGY.

CHAPTER V.

THE EVOLUTION OF THE NERVOUS SYSTEM.

THE nervous system of man is so exceedingly complex that a study of simpler nervous systems is not only desirable but absolutely necessary if its form and functions are to be understood. Believing that man is the highest product of animal evolution and that he has evolved through countless generations from a primordial living cell, we endeavour in this chapter to give an account, if only in outline, of how his nervous system has come to be. The elaboration and filling in of details must be left to the further studies of the reader. Many of the natural orders of the zoologist will be omitted, but a few examples or types will be considered.

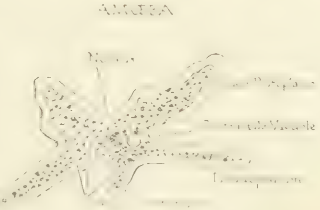

FIG. 8. The Amoeba.

Amoeba. The lowest forms of animal life known to the zoologist are the unicellular animals classed as *protozoa*, and of the protozoa the amoeba or *proteus animalcule* is one of the simplest.

The amoeba, which is just visible to the naked eye, consists of an irregular mass of protoplasm slightly differentiated into an outer clear protective portion and an inner granular portion. Near the centre may be observed a nucleus and there is also a primitive excretory organ known as a vacuole. If the amoeba is cut in two, the part containing the nucleus continues to live, hence the nucleus is necessary to the life of the cell. The granules are for the most part undigested food remnants. The amoeba moves by throwing out pseudopodia (false feet) and it eats by wrapping itself around its food and digesting it. When the limit of growth has been reached, the amoeba divides itself into two parts through the centre of the nucleus and two daughter cells are thus formed. The amoeba exhibits all the functions of animals—it is reproductive and irritable, it can digest, breathe and move. It is diffusely sensitive to contact, changes of temperature, light, and chemical and electric stimuli. Yet no part of the animal is superior to another; the amoeba may be said to be all digestive apparatus, all nervous system, all muscle, etc., at one and the same time.

The evolution of the nervous system consists of the differentiation of parts. Instead of the whole animal being sensitive as is the case with the amoeba, we get certain parts specialised to receive sensory stimuli. These parts are known as *receptors*. Other parts become muscular and are specially concerned with movements and other responses to stimuli; these are known as *effectors*. A third portion of the animal organism becomes specialised to conduct the stimuli received by the receptors to the movement-producing effectors; this portion becomes the nerve system proper and the parts concerned are known as *conductors* or *connectors*. The amoeba is quite unspecialised so far as receptors, conductors and effectors are concerned.

Paramoecium. The paramoecium is a slightly higher type of protozoa. It has a definite shape (oval) and moves by means of cilia arranged in a spiral form on its surface.

There is a definite opening for the ingestion of food and a primitive alimentary canal. As in the amoeba there is a contractile vacuole. Two nuclei are present—a micro and a macro nucleus; the former is concerned with reproduction only and the latter with the ordinary functions of the cell. Special sting cells or trichocysts occur among the cilia. The reactions of this animal to stimuli are, however, far more complicated than those of the amoeba. If a paramoecium in its more or less forward corkscrew movement meets an obstacle, it backs, stops, turns through a small angle and then forges ahead again. The reactions to temperature are also perfectly definite. In water of 19° C. paramoecia scatter themselves fairly regularly. If one end of the vessel is heated or cooled they strive to reach that part which is nearest in temperature to 19° C. If acetic acid is poured into the tank, the animals cluster together and thus tend to preserve the lives of those in the centre of the clump. The reactions to light and electrical stimuli are also fairly elaborate.[1] We thus see that although the effectors of the paramoecia are somewhat specialised and they behave in a far more complex fashion than amoebae, they can hardly be said to show even the beginnings of a nervous system.

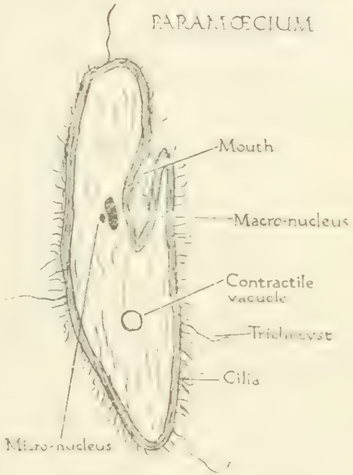

FIG. 9. The Paramoecium.

Sponge. The sponge, one of the lowest of the metazoa, is interesting from the fact that it is the first animal to attain any success in the formation of a "body," though this body shows little unification and correlation. The lack of co-ordination of parts is shown by the fact that if the sphincter at the mouth of the sponge is closed by touching it, the cilia of the pores are not checked but go on lashing the water inwards and towards the mouth, in spite of the fact that there is no outlet and the action is therefore useless. Here again we get specialised effectors but little specialisation of receptors or conductors. The sponge is on a sideline of evolution and does not lead to higher forms.

Hydra. The hydra (*Coelenterata*) is a multicellular animal showing distinct receptors, conductors, and effectors. The hydra has thus a primitive nervous system which serves as the connecting link between primitive sense organs and primitive muscle cells.

The hydra consists of a two-layered tube with a crown of sensitive tentacles around the mouth. The great simplicity of structure is made evident by the fact that if the hydra is cut into two parts each portion has the power of growing into a complete hydra. The inner layer of cells or endoderm is chiefly concerned with the digestion of food and with respiration, and hence remains soft and insensitive; the outer layer or ectoderm contains epithelial supporting cells, muscle cells, nerve cells and sensory cells. The latter are scattered irregularly through the ectoderm, but are invariably connected with a muscular cell. The nerve cells proper may be looked upon as peripheral sensory cells which have migrated to the interior and become still more specialised. They are of two kinds: (1) motor nerve cells which are directly connected with muscle cells, and (2) connecting or interpolated nerve cells which serve as the connecting links between sensory and motor nerve cells. The conductors of the hydra are connected up throughout the length of the animal into a simple cord and the larger ganglia (masses of nerve cells) found near the mouth may be said to be the primitive beginnings of a brain.

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[1] See Jenning : *Behaviour of the Lower Organism*

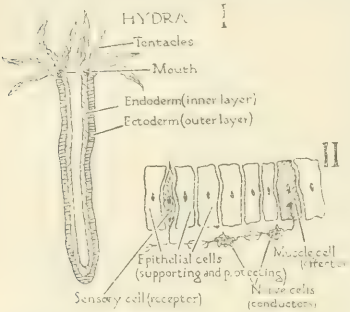

FIG. 10. The Hydra. I. General view (semi-diagrammatic). II. Diagrammatic representation of a part of the ectoderm showing a sensory cell, a motor nerve cell, an interpolating nerve cell and a muscle cell.

Medusa. The medusa or jelly fish (*Coelenterata*) may be looked upon as an inverted free swimming hydra. The "umbrella part" has a ring or network of nerve tissue around the edge and this is connected up with the motor organs and with the sensitive tentacles and the specialised receptors placed around the rim. The nervous system is not yet essential to the life of the animal: it simply enables it to react more rapidly. The specialised receptors of the rim are concerned with the rhythmical muscular movements of the animal, and so long as one is left, the movements persist. Cut all of them away and movement ceases. Conduction is thus general and takes place in both directions.

"Universal and indiscriminate conduction, limited only by a dying out of the influence connected with the distance traversed, is the characteristic of this simplest type of nervous system."[1]

Earthworm. The next group which shows any marked specialisation is the *Annelida.* This consists of animals with a bi-lateral symmetry and exhibiting a tendency towards segmentation. Each segment is only partially controlled by the head. This segmentation persists throughout the whole of the animal kingdom and even in man himself it is not wholly lost, for the chest has circular muscles and the spinal cord is distinctly segmented. The nervous connections in the higher animals are, however, so numerous that, from a single stimulus, we get responses extending over a very wide area.

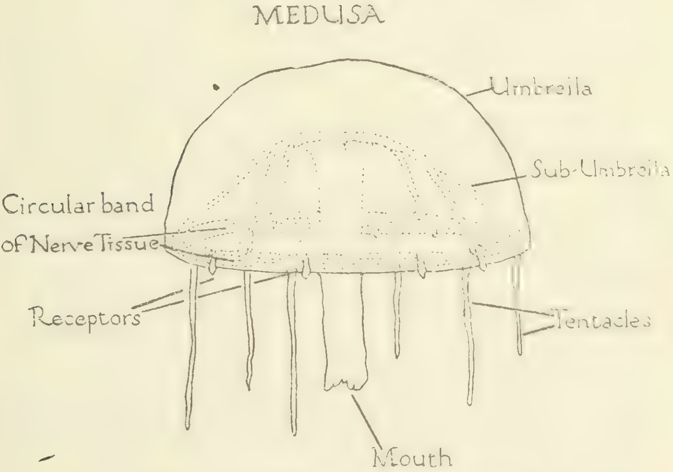

FIG. 11. The Medusa or Jelly-Fish (schematic).

As an example of the Annelida we may take the common earthworm. The earthworm has a cylindrical body composed of numerous segments with a food canal running from end to end. The animal moves by the contraction of its muscular tissue, which is arranged in circular and

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[1] Ladd and Woodworth: *Elements of Physiological Psychology*; p. 20.

longitudinal bands beneath the skin. Special muscular tissue occurs round the mouth in connection with the organs for seizing food. In each segment along the mid-ventral line a pair of nerve ganglia occurs which is connected with the succeeding segments by means of nerve cords. These two segmented cords diverge at the anterior end to form a ring or oesophageal commissure round the pharynx. They come together on the dorsal surface and form the cerebral ganglia in the first segment of the animal. The cerebral ganglia give off nerves to the sensitive cells which occur in the skin on the dorsal surface of the head.

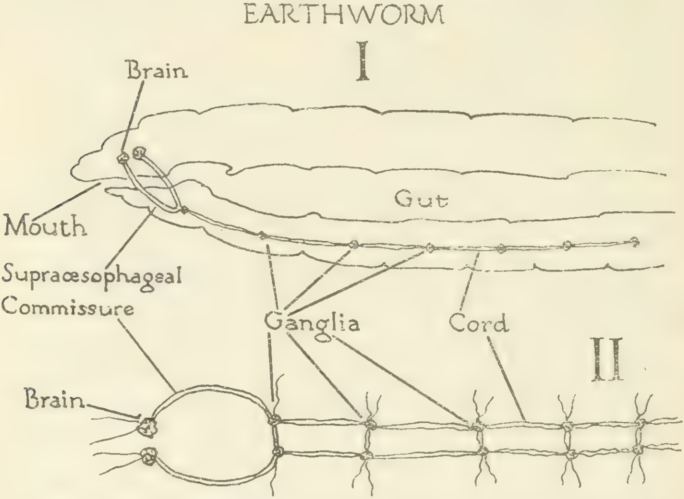

FIG. 12. The earthworm. I. Anterior end of worm. II. Diagrammatic representation of nervous system.

The destruction of the spinal cord makes little difference to the earthworm, for each part continues to move when it is cut in two. This shows that the segmental ganglia are centres of co-ordination of nervous action.

The annelids are a distinct advance on the coelenterates, for the nervous fibres are banded together to form nerves instead of being diffused to form a nerve net. The connection between the receptors and effectors is invariably by way of the central nervous system. The cell bodies of the receptor cells are external to the ganglia, while the cell bodies of the motor nerves are in the central ganglia. This arrangement of sensory and motor nerve cells persists in all higher forms.

Arthropods. The next higher group showing a centralised nervous system is the *arthropoda*. This group is subdivided into various sub-groups of which the *crustacea* (crabs) and insects are the best known. The animals of this group preserve the segmented form of the worms although their nervous system is superior in many respects. There is a higher development of the cerebral ganglia, and the connecting links of the ganglion chain are far more numerous. The commissure is still to be found in all members of this group.

Vertebrates. We now arrive at the vertebrates or animals possessing a backbone. These, in order of complexity, are : *fishes*, *amphibia*, *reptiles*, *birds* and *mammals*.

The complexity of these animals is so great that detailed descriptions are out of the question. Only a few of the more important features of the nervous system can be mentioned.

In the annelids and the arthropods we saw that there were two symmetrical segmented cords arranged ventrally. In the vertebrates these cords have not only developed to such an extent that they appear continuous, but they have also fused together to form a single cord with a central canal. This central canal can be traced to the foremost end of the brain. The whole central nervous system has also changed its position and now lies dorsally above the alimentary canal. It is also surrounded by a bony covering to protect it from injury. In one of the lower fishes—the *Balanoglossus*—the transitional form of nervous system is seen, for it has both a ventral and a dorsal cord.

The vertebrates also show an increasing domination of the brain over the rest of the nervous system. In the *Amphioxus* (a fish) there is little differentiation between the brain and spinal cord ; in the *craniata* (animals with skulls) the two are distinctly marked off from one another.

There is also a difference in the position and arrangement of the sensory cells. In the worms and crabs the sensory cells were placed at the periphery and the connections with the central system were made by long cell processes. The vertebrates, however, have the sensory nerve cells placed near the spinal cord and these connect up with specialised receptors at the periphery by nerve fibres, called axons. In the sensory nerves of smell the primitive invertebrate form still exists and the connection with the brain is still by means of sensory cell processes.

The brains of the higher vertebrates are invariably composed of the following five parts: (1) the *myelencephalon* or *medulla oblongata*; (2) the *metencephalon*, which is roofed over with the *cerebellum*. The cerebellum is supported by pillars which thicken ventrally forming a protuberance known as the *pons varolii*; (3) the *mesencephalon* or mid-brain. The dorsal wall is divided longitudinally by a furrow into two optic lobes, and again transversely, thus making four bodies which are known as the *corpora quadrigemina*; (4) the *diencephalon* or inter-brain, the lateral walls of which form the *optic thalami*. The optic tracts as they enter the inter-brain form a cross at what is known as the *optic chiasma*; (5) the *telencephalon* or fore-brain, which is greatly enlarged in the higher animals and constitutes the bulk of the brain. The fore-brain of all animals above reptiles is divided into two lateral lobes known as the cerebral hemispheres. The cerebral hemispheres are connected one with another by bands of commissural fibres, the chief of which is the *corpus callosum*. The cerebrum is divided into the *neo-pallium*—that part of the brain which is concerned with "visual, auditory and general body sensations, with voluntary actions and with all the complex associational processes involved in our more highly organised activities, and in the formation and expression of ideas";[1] and the *archi-pallium*—that part which is devoted to olfactory and, possibly, gustatory functions. The neo-pallium divides its labour and so we get the "localisation of brain functions." The cerebral hemispheres are connected with the rest of the brain (viâ *thalamus*) by a thick bi-lobed mass consisting of collections of nerve cells and pierced by numerous large bundles of fibres known as the *corpus striatum*.

In the lower vertebrates the brain is little more than an organ for the reception of sensory stimuli. The fore-brain is mainly concerned with smell, the mid-brain with visual impressions, and the hind-brain with hearing, taste and the vital functions of the body. In the higher vertebrates more complex functions develop owing to the large increase of the number of association fibres.

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[1] Johnston: *The Nervous System of Vertebrates*; p. 343.

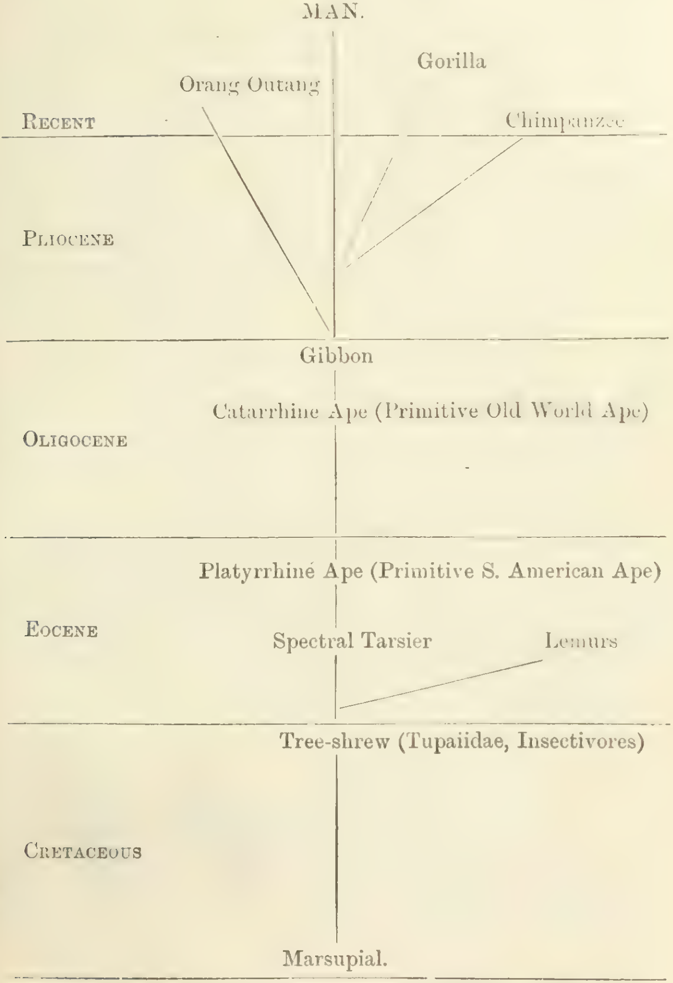
MAN.
Gorilla
Orang Outang
RECENT
Chimpanzee
PLIOCENE
Gibbon
Catarrhine Ape (Primitive Old World Ape)
OLIGOCENE
Platyrrhiné Ape (Primitive S. American Ape)
EOCENE
Spectral Tarsier
Lemurs
Tree-shrew (Tupaiidae, Insectivores)
CRETACEOUS
Marsupial.

FIG. 13. Elliot Smith's "tree" of the later evolutionary forms of Man.

Quite recently[1] Elliot Smith has traced the later evolution of man by means of a comparative study of brains. His genealogical tree is roughly indicated in the diagram (Fig. 13).

Eyes and Ears. The development of specialised sense-organs such as the eye and the ear is also of interest. We saw that unicellular organs responded to light. Some even react to colours. As the number of cells in an animal increases, a specialisation of functions occurs. The first development towards a sensory organ for light is the formation of pigment spots with specialised sensory cells beneath them. The pigment probably absorbs light. Above the pigment spots simple lenses develop and these concentrate the light. Development also proceeds in the receptor cells, and mechanisms for the enhancement or reinforcement of the delicate light stimulus are evolved. In the insects there is a fixed eye with an enormous number of facets, each of which is complete in itself. The vertebrate eye has evolved in the direction of a single organ with power of movement. It has accessories for concentration of the rays (cornea), for focussing (lens, etc.) and for movement or direction (muscles).

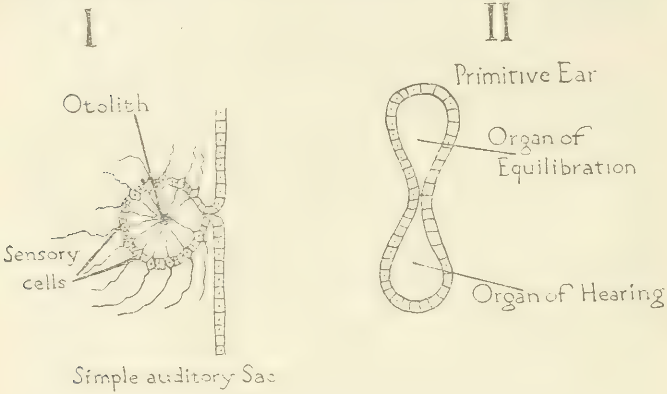

FIG. 14. Simple auditory apparatuses. I. Simple auditory sac. II. A primitive form of ear showing division into two parts.

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[1] Presidential Address to the Anthropological Section of British Association at Dundee, 1912.

The ear has developed out of cells which became specialised to respond to movements in water. The first ear consisted of a simple sac filled with a fluid and lined with special sensory cells.

The sac was at first open, and consequently solid particles (*otoliths*) would enter by accident and serve as excellent indicators of movements in the water. When the sac became a closed one, the otoliths had to be grown by the animals, for they were by this time indispensable. Such an organ would respond to two types of stimuli: (1) to movements outside the body and (2) to movements inside the body. The sac in its evolution divided into two parts—one of which was concerned with hearing and the other with balance. The hearing part ultimately became the *cochlea*, while the part concerned with equilibration developed into the *semi-circular canals*.

References. Crichton Browne: *Growth, Somatic and Cerebral*; Child Study, IV., Oct. 3, 1911. Donaldson: *The Growth of the Brain*. Foster: *Text-Book of Physiology*. Jennings: *Behaviour of the Lower Organisms*. Johnston: *The Nervous System of Vertebrates*. Ladd and Woodworth: *Elements of Physiological Psychology*. Loeb: *Comparative Physiology of the Brain* and *Comparative Psychology*. McDougall: *Physiological Psychology*. Sherrington: *The Integration of the Nervous System*. Thorndike: *Elements of Psychology*; Chap. IX.

CHAPTER VI.

THE CONSTITUTION, FUNCTIONS AND ACTION OF THE NERVOUS SYSTEM.

Gross structure of the Nervous System. In tracing the evolution of the nervous system the following parts were noted: (1) The central nervous system, consisting of the spinal cord and the brain; (2) the nerves or bundles of nerve fibres which connect the central nervous system to the periphery of the body; and (3) the specialised end organs at the periphery which receive the stimuli external to the nervous system. To these three parts must now be

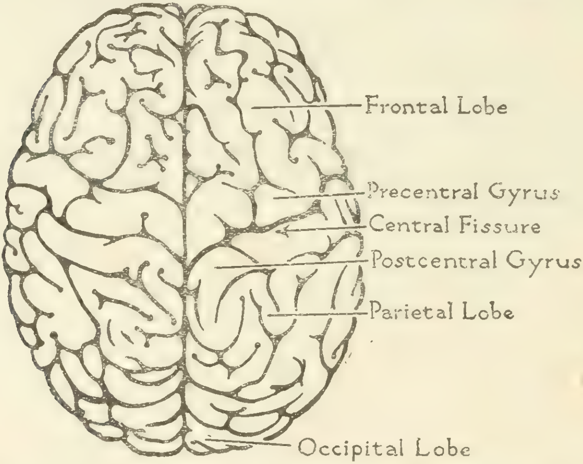

FIG. 15. View of upper surface of brain showing fissures, gyri and lobes.

added a fourth, namely, the sympathetic system, which is mainly concerned with the control of the muscles of the circulatory system and the viscera.

The Brain. The brain or *encephalon* consists of those parts of the central nervous system which are contained within the cavity of the skull. When in its normal position the brain (and spinal cord also) is surrounded by three membranes, namely, the *dura mater*, which lies next the skull and remains attached to it when the brain is removed, the *arachnoid*, and the *pia mater*—a vascular membrane full of minute blood vessels.

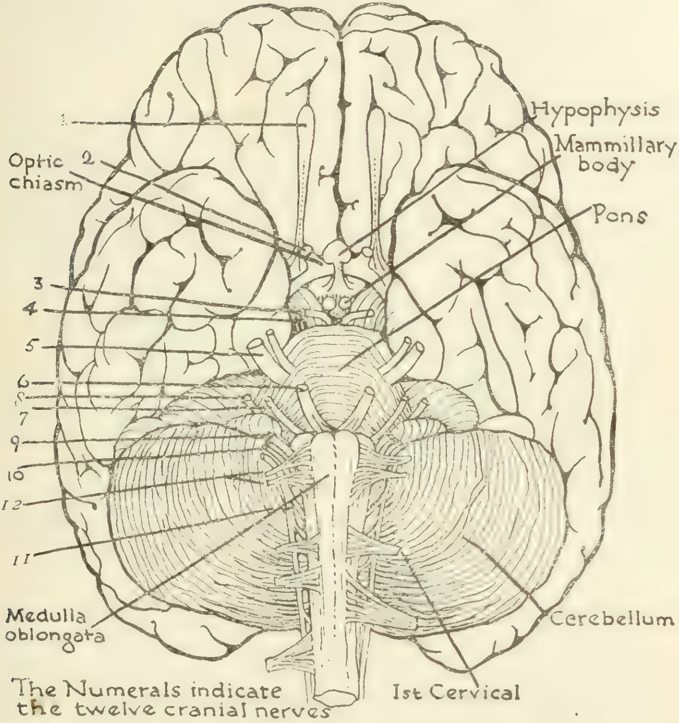

FIG. 16. View of under surface of brain with nerves numbered (after Henle and Van Gehuchten).

On the removal of the brain from the skull the most conspicuous parts are the *cerebrum* and the *cerebellum*. The former is convoluted and is divided longitudinally into the two cerebral hemispheres by a deep median fissure. The fissures and convolutions (*lobes* and *gyri*), though varying slightly in different brains, remain fairly constant and hence may be named and classified. The most noted of the cerebral fissures are those of *Silvius* and *Rolando*. The fissure of Rolando is also known as the Central Fissure. A mesial section of the brain shows that the cerebral hemispheres are united latitudinally by the corpus callosum. Any other section of the brain shows that it is composed of two layers—an outer grey layer from $\frac{1}{8}''$ to $\frac{1}{4}''$ thick, known as the *cortex*, and an inner white mass composed mainly of medullated (or myelinated) nerve fibres. The cortex controls the higher thought processes. The fibres are grouped into three systems: (1) the *Projection System*, which connects the cortex to the lower parts of the nervous system; (2) the *Association System*, which connects the

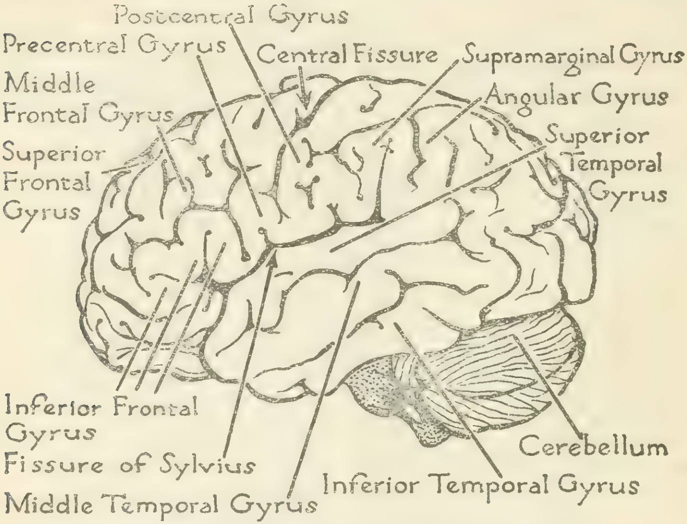

FIG. 17. View of left side of brain showing cerebrum and cerebellum.

various parts of the Cortex both near and remote one with another; and (3) the *Commissural System*, which connects the left and the right sides of the brain together.

Twelve pairs of nerves are directly connected with the brain—six with the medulla oblongata and six with the parts of the brain anterior to the medulla. The first is the olfactory nerve or nerve of smell; the second is the optic nerve; the third, fourth and sixth are the nerves which supply the eye muscles; the fifth is the trigeminal; the seventh or facial nerve goes to the muscles of the face, mouth and lips and so controls facial expression; the eighth is the auditory or nerve of hearing; this has two distinct groups of fibres—one connected with the cochlea (hearing), the other with the semi-circular canals of the ear (equilibrium); the ninth or glosso-pharyngeal goes to the tongue and pharynx; the tenth is the vagus nerve, which supplies motor and sensory fibres to the larynx, windpipe, lungs, heart, gullet, stomach, pancreas and the upper part of intestine; the eleventh or the spinal accessory supplies the muscles of the neck; and the twelfth or hypoglossal is the motor nerve of the tongue.

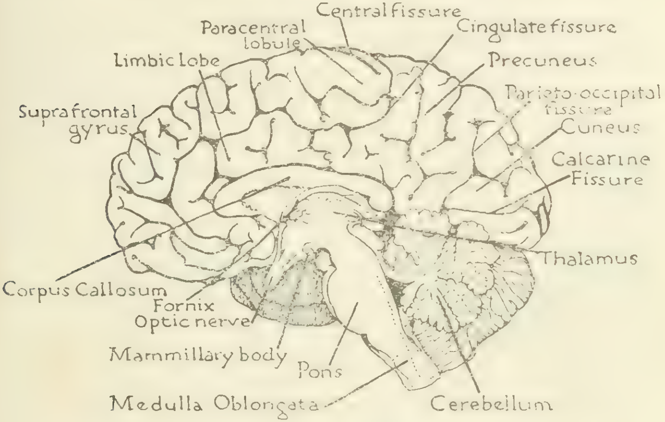

Fig. 18. View of mesial section of brain showing right hemisphere (after Edinger and Retzius).

The *cerebellum* consists of three lobes—two large lateral ones and a small middle one known as the *vermis*. The surface is folded into numerous fissures, but these are not so deep as in the cerebrum. There is good reason to suppose that the cerebellum is concerned with the co-ordination of the muscles of the body, and hence with all bodily movements and with the maintenance of the upright posture. The exercise of these functions as a rule is not attended with consciousness and consequently does not arouse our attention.

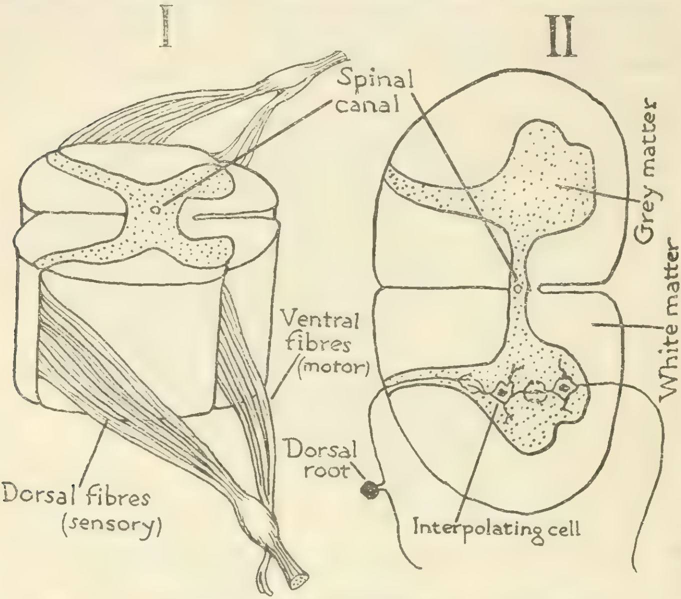

FIG. 19. Two views of spinal cord showing white and grey matter, and motor and sensory fibres.

The *spinal cord* in fishes extends from the brain to the end of the spinal column; in man it ends in the lumbar region, except for a fine continuation (*filum terminale*) which runs to the end of the *coccyx*. Its method of evolution is shown by two fissures which almost divide it into two parts along its whole length—the ventral or anterior in front and the dorsal or posterior at the back. A section of the spinal cord shows that it is composed of two parts, the white and the grey matter. The white matter consists of nerve fibres connecting up the various parts of the cord with the other parts and also with the brain above.

The grey matter, shaped like the letter H, is composed of motor and connecting nerve cells. Each spinal nerve as it enters the cord divides up into two parts. The sensory fibres enter the dorsal horn of the grey matter, which is long and narrow, and the motor fibres leave by the ventral horn, which is short and thick. The thickness of the ventral horn is due to the fact that it contains the cell bodies of motor cells in very large numbers.

The Sympathetic System. This consists for the main part of two chains of nerve ganglia running parallel and near to the spinal cord. The sympathetic system was evolved contemporaneously with the central nervous system, and the connection between them is still a close one. The ganglia of the sympathetic system are, as a matter of fact, the result of migrations of nerve cells from the dorsal and ventral roots ganglia of the spinal cord. The branching nerves of the sympathetic system are connected with the viscera and blood-vessels of the body on the one hand, and with the spinal cord on the other. The sympathetic system, through its control of the blood supply and the vital organs of the body, is closely associated with our emotional life.

Localisation of Brain Functions. The fact that the cortex of the cerebrum is the organ of the higher thought processes and that certain fairly well-defined areas are specialised for certain functions is now removed beyond the region of speculation. The evidence obtained from partial injuries to the brain, from diseases of parts, from experimentation by electrical stimulation and extirpation of parts, from experimentation with anthropoid apes, from comparative anatomy and from the actual tracing of nerve fibres, is now conclusive.

As was pointed out earlier in the chapter, the convolutions of the brain are fairly definite in man. In order, however, to make the description of parts easier it is usual to divide up the cerebral cortex into four lobes. These are: (1) the *frontal lobe*, which lies in front of the Rolandic fissure and above the fissure of Silvius; (2) the *parietal lobe*, lying behind the fissure of Rolando and above the fissure of Silvius: it is partially divided from the occipital lobe by the parieto-occipital fissure—one of the deep fissures of the mesial brain surface; (3) the *temporal lobe*, lying below the fissure of Silvius and in front of the occipital lobe; and (4) the *occipital lobe*, which forms the posterior part of the cerebrum. The lobes are again divided into *gyri*, each of which is named, so far as is possible, from its position on the brain surface (see Figs. 15 to 18).

The motor area. This was one of the first to be mapped out and is one of the best known by reason of the ease of its exploration by electrical stimulation. It lies in the *pre-central gyrus* of the frontal lobe along the fissure of Rolando. The upper parts of this area control, through the lower motor nuclei of the spinal cord, the muscles of the lower limbs; as we descend the gyrus the muscles of the trunk, arm, neck and head are controlled in what may be roughly described as an ascending order. The muscles of the eyes, however, are not controlled by this area of the cortex but by an area lying in the middle and inferior frontal gyri. Disease or injury of the left motor area causes paralysis of the right side of the body.

The sensory area. This area is parallel to the motor area and lies on the opposite side of the Rolandic fissure in the part of the parietal lobe known as the *post-central gyrus*. It is concerned with cutaneous and muscular sensations. Neighbouring areas of the parietal lobe probably help in the elaboration or perception of the sensations, but nowhere do the sensory and motor areas overlap.

The visual area. Practically the whole of the occipital lobe is concerned with vision, but more especially that part lying on the mesial surface near the *calcarine* fissure. The optic nerves at the optic chiasma suffer a partial decussation (crossing) and the fibres, now known as the optic tracts, pass on and divide themselves among the *thalamus*, the *lateral geniculate bodies* and the upper parts of the *corpora quadrigemina*. From these three mid-way stations the tract continues as the *optic radiation* until the occipital lobe is reached. Injury to the visual area causes cortical blindness or inability to see things, although the eyes are perfect. Injury to the right side of the cerebrum in this region causes a semi-blindness, and nothing lying in the left field of vision can then be seen.

The auditory area. The *superior temporal gyrus* and the transverse gyri extending from this into the fissure of Silvius are universally acknowledged as the centre for hearing. As animals move their ears when this part of the cortex is stimulated, it is more than probable that the area is motor as well as sensory.

The olfactory centre. This centre is not definitely known. Certain it is that the sensory olfactory fibres first pass to the olfactory bulb and thence along the olfactory tract to the *hippocampal* lobe. This lobe, which is most probably the seat of smell, is both sensory and motor. The olfactory centre is in the archi-pallium ; the others mentioned previously are parts of the neo-pallium.

The gustatory centre. The centre for taste is not definitely known. It probably lies in the hippocampal convolution.

The association areas. The brain of man differs from that of the highest ape mainly in having larger "silent areas" or parts of the cortex apparently unconnected with sensory or motor stimuli. These areas have been called association areas because of the well-founded belief that they are concerned with the association (in a physiological rather than psychological sense) and unification of the sensory and motor functions of the brain. Three of these areas have been named. The largest is that found in the frontal lobe and is known as the *frontal association area.* The other two are the *median association* area and the *posterior* or *parieto-temporal association* area. The fibres of the association areas become medullated (myelinated) at a later date than the motor and sensory fibres of the brain, hence Flechsig assumed that these centres were the organs of the higher thought processes.

Centres connected with Language. Four areas of the brain closely connected with speech, writing, auditory perception of words, and visual perception of words have been partially mapped out. The exact localisation of the centres is still very indefinite owing to the fact of our dependence upon pathological conditions for the study of them. Moreover, the inter-dependence of the various centres seriously complicates the process of demarcation. In the study of the various *aphasias* (defects connected with speech) a body of undoubted facts has come to light. It is now fairly certain that the inferior frontal convolution of the left hemisphere is especially concerned with the power of speech in right-handed persons, and the corresponding part of the brain with the speech of left-handed persons. Injury to this region produces a motor type of aphasia or

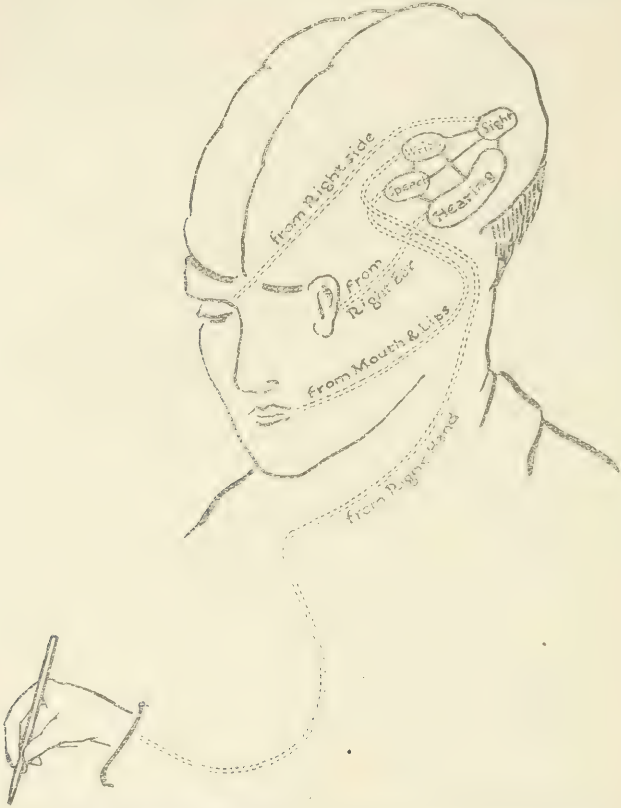

Fig. 20. (Lapage.) Diagram to show the position in the brain of the four centres that have to do with the reception, the production and the storing-up of memories of speech, reading and writing. Note the association fibres joining up the four centres, each with the other three.

inability to utter articulate language. A person suffering from this defect may still be able to understand what is said to him and to express himself intelligently in writing. Pierre Marie (1906) considered that there must always be a more deeply seated injury (sub-cortical) before an aphasia of this type resulted, but opinion is now veering around to the original view of Broca—the discoverer of the speech centre (1861-5).

The writing of sounds heard depends upon the integrity of the motor centre for the arm. The writing centre is generally supposed to lie in the *second frontal gyrus* just in front of the motor centre for the hand and above the speech centre of Broca. Injury to this centre produces a second type of motor aphasia (*agraphia*)—the inability to write language.

Injury to the cortex in the inferior parietal convolution contiguous to the occipital visual centre produces a peculiar type of sensory aphasia known as *alexia* or inability to recognise printed words. This word-blindness or inability to read is not due to any defect of vision; the patient can see the words quite clearly but they are now quite meaningless. The inability to learn to read which is found in some apparently normal children may probably be due to alexia.

A sensory aphasia of the auditory type (word-deafness) is produced by lesions of the superior temporal convolution contiguous to the auditory centre in the temporal lobe. The patient can hear spoken words but they convey no meaning. Much work remains to be done both by anatomists and physiologists before these important problems of language functions are finally solved.

The finer structure of the Nervous System. Having obtained a general idea of the nervous system as it appears to the naked eye, we now proceed to a description obtained through the instrumentality of the microscope. The whole nervous system is composed of minute nerve cells called *neurones*. These are extremely numerous, and although the number can only be estimated, it is known that there are several thousand millions of them. The orderly connection of this vast array of neurones is at the basis of all our mental life.

According to function, neurones may be classified as *sensory* (afferent or centripetal), *motor* (efferent or centrifugal), and *interpolating* (connecting or associating) neurones. But whatever the function, all neurones consist of a cell body, which contains the nucleus, and two or more branching processes of a fibre-like nature. The number of the processes determines the polarity (number of branching processes from cell body) of the cell. A sensory neurone is bi-polar, while motor and interpolating neurones are multipolar. One process in sensory and motor neurones is much longer than the other and is known as the *axon* or *axis-cylinder process*.[1] All the other cell processes are known as *dendrons* or *dendrites*. These are much shorter and are usually branched like the boughs and twigs of an oak tree.

The axons are composed of *neuro-fibrils* and *neuro-plasm*, and there is reason to suppose that only the former are concerned with the conduction of the nervous impulse. They are often sheathed with two coverings—the *sheath of Schwann* on the outside, and the fatty *medullary* or *myelin sheath* on the inside. As the axons are bundled together to form nerves, these sheaths serve as insulators and help the neurones to preserve their individuality. The axons of a nerve fibre may thus be compared to the separate wires of a trunk telephone line. It is probable that the medullary sheath in addition to insulation assists also in the nutrition of the cell. Axons may, however, be connected with other axons by means of fine connectors known as *collaterals*. Collaterals are most numerous in the central nervous system and especially in the brain. Section of an axon or dendron causes degeneration (Wallerian, from its discoverer) of the fibre on the side remote from the cell-body.

Cell-bodies of motor and interpolating neurones are irregular in shape and are invariably constituent parts of the central nervous system. Those of sensory neurones are fusiform (tapering at both ends like a spindle) in shape and are external to the spinal cord. The cell-bodies of sensory cells form the posterior root ganglia of the spinal nerves.

Specialised forms of motor and interpolating neurones have been discovered in various parts of the central nervous system. The most interesting of these are the *Purkinje* cells of the cerebral cortex with their large cell-bodies and their enormously complex network of nerve fibres, and the *Pyramidal* cells of the same region, which are the elements of the projection system of nerves.

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[1] Some authorities call the branched process of the motor neurone the axon, in order to bring all processes receiving stimuli within the same category.

The junction of one neurone with another is known as a *synapsis* (or *synapse*). Such junctions are invariably within the central nervous system. Whether or not there is a continuity of nerve substance at the synapsis is still open to doubt. Actual connections have been observed in the spinal cords of animals, but even then the substance joining the two neurones seems to be of a different constitution from that of the neurones. If we suppose that at first there is a minute gap between all neurones and that the passage of nervous impulse from one to the other becomes easier with use (from the actual growth of connecting links or in other ways), we can explain most of the phenomena of nerve conduction across a synapsis. There is no doubt that there is a resistance at the synapsis to the passage of nervous impulses, that this resistance decreases as the number of nervous discharges across the synapsis increases, that the resistance is increased by certain drugs such as cocain, chloral, chloroform and alcohol, while it is decreased by others such as strychnine and tannin (tea), and that the discharge takes place in one direction only. Some writers have looked upon the synapses as the seat of consciousness. It is certain that they are intimately concerned with the formation of neural habits.

The medullation (myelination) of axons is closely associated with the functioning of the neurones of which they form part. It is certain that functioning is possible before the axons myelinate, but, on the other hand, it is probable that myelination increases their efficiency. Flechsig, from his studies of myelination, came to the conclusion that the development of the functional power of the brain areas was contemporaneous with the medullation of the nerve fibres supplying those areas. If this be the case, we can argue that the mental tasks of school children should be arranged so as to correspond somewhat with the order of the myelination of the fibres they are chiefly dependent upon for their correct performance.

The action of the Nervous System. Neurones are parts of the body which have become specialised for *sensitivity*, *modifiability* and *conductivity*.

Sensitivity. In our study of the evolution of the nervous system we found that in the lowest of the multicellular animals certain cells had become more sensitive than others. They existed for the purpose of informing the remainder of the body what was the condition of, and what changes were taking place in, the environment. This sensitivity in higher animals became still more specialised. The neurones of man are far more influenced by what happens to them than are muscle or bone cells.

Modifiability. This means that the passage of a nervous impulse through a neurone changes it in some peculiar manner which is not yet understood. The resistance at the synapses is reduced. The passage of a similar current along the same track tends to arouse in us a knowledge of the cause of the first current.

Memory is thus intimately associated with the modifiability of neurones. In the same way habit and association and in fact all mental life is bound up with this basic function of neurones.

Conductivity. Although nerve tissue has the greatest power of conductivity, it is not unique in this particular property: muscle cells will conduct. Nerve fibres as a rule are only stimulated at the ends, motor at central, sensory at the peripheral end, yet any nerve fibre may be stimulated artificially at any point of its course by any of the following stimuli: chemical stimuli, such as acids and alkalies, mechanical stimuli such as jolts and jars (cf. the so-called "funny bone"), thermal stimuli (ineffective so far as motor fibres are concerned, but very effective with sensory fibres, cf. fingers numb with cold), and electrical stimuli both at the make and break of the current. The impulse is not conducted instantaneously. With suitable instruments its velocity can be fairly accurately determined. Helmholtz found that between 11° C. and 21° C., it passed at the rate of 24·6-38·4 metres per second along the sciatic nerve of a frog, and that the rate in man was about 34 metres per second. Piper, however, by using a more refined method of measurement, found that the velocity was from 117-125 metres per second. Hence the phrase as "quick as thought" must not be interpreted to mean a velocity infinitely great. It is worthy of note that the velocity of the impulse is one of the factors in reaction-time, *i.e.* the time it takes to react to a given stimulus.

There have been three theories of conduction, namely: (1) that it is due to the flow of animal spirits or a nerve juice or fluid through the nerves; (2) that it is of a nature comparable to the transmission of light or electricity; and

(3) that it is of the nature of the energy of chemical action. The first is known to be false; contemporary scientific opinion wavers between the electrical and the chemical theories and tries to effect a combination of them. Whatever the nature of conduction certain facts with respect to it deserve notice. These are—(1) Conduction takes place usually, if not always, in one direction only, and that a forward one; (2) Sensory and motor axons behave differently with respect both to temperature and to direction; (3) Certain influences modify conduction—drugs, temperature and pressure; (4) It is very difficult to fatigue a nerve fibre and so prevent conduction from taking place. Either nerve fibres cannot be fatigued or else they have the power of very rapid recovery. It is probable that the latter statement represents the facts more correctly.

Specific energy of Nerves. The doctrine of specific nervous energy states that each sensory nerve gives rise to its specific sensation no matter what kind of stimulus is applied. The apparent similarity of action under different stimuli may be a fundamental property of the nerves or the unifying factor may be the central nervous system to which they are attached. Experiments on the "crossing" (*i.e.* of attaching sensory to motor fibres by first cutting and then allowing the ends to grow together) of two nerves seem to show that it is the organ to which they are attached and not the specific energy of the nerve, which leads to the similarity of results under different stimulations. There is little doubt, however, of certain facts connected with the problem. Excitation of the optic nerve by electrical and mechanical stimuli is invariably followed by sensations of sight; dust and other mechanical stimuli are effective in stimulating the sense of smell; while the cold spots of the skin give rise to feelings of cold even though they are touched with a hot body. A hot bath often produces feelings of chilliness when the water first touches the lumbar region (small of the back) where cold spots are known to be very numerous.

There are difficulties in the way of a complete acceptance of the doctrine if we consider the separate fibres of the nerve as conducting qualitatively different sensations. Are there fibres in the optic nerve which respond to one only of a thousand possible colour stimuli? Are the apparently simple sensory fibres of the nose differentiated to respond to all the gradations of recognisable smells? It is true that the difficulties with respect to hearing and cutaneous sensations are not very great, for it is known that there are from 16,000 to 20,000 distinct units of auditory end-apparatus corresponding to the different musical tones,[1] while the sensory "spots" of the skin are so numerous as to defy counting, yet the doctrine in its widest meanings cannot as yet be accepted. Further investigation is needed to establish it completely.

The Laws of Brain Action. Thorndike[2] gives the following laws of brain action:

1. *The law of expression.* Every stimulus of a sensory neurone must have some result: it cannot come to nothing. This does not necessarily mean that the result is visible in some movement or other. The result may be a hidden modification of the nervous system or may be some inhibition of movement.

2. *The law of least resistance.* When any neurone is stimulated it will conduct along the line of least resistance, or in other words along the line of strongest connection. Habitual use of a nerve tract so alters its substance that it becomes the line of strongest connection. It is then difficult to act in any but an habitual manner when this tract is stimulated.

3. *The law of inborn connections.* This law runs: 'that, other things being equal, any neurone group will discharge into the neurone group with which it is by the inner growth of the nervous system connected.' Generally speaking, the sensory nerves from the periphery are naturally connected with motor neurones running to muscles in the same neighbourhood. Because of inborn connections we move the hand when it is pricked or tickled, rather than other and unrelated parts of the body.

4. *The law of acquired connections.* "When any neurone group, A, is stimulated, the nervous impulse will be transmitted to the neurone group which is most closely connected with group A, which has been aroused by A most frequently, with most satisfaction to the individual, most recently, most energetically and for the longest time, and which is the most sensitive at the time."

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[1] Ladd and Woodworth: *Elements of Physiological Psychology*; p. 351.

[2] *Elements of Psychology*; p. 162 ff.

This law, subject to modification induced by fatigue and the various "moods" of an individual, is undoubtedly of the greatest service to psychology, inasmuch as it provides us with a physical or mechanical explanation of some of the most abstruse and difficult mental phenomena.

References. Donaldson: *The Growth of the Brain.* Ferrier: *Functions of the Brain.* Howell: *Text-Book of Physiology.* James: *Principles of Psychology.* James: *Text-Book of Psychology.* Ladd and Woodworth: *Elements of Physiological Psychology.* Loeb: *Comparative Physiology of the Brain and Comparative Psychology.* McDougall: *Physiological Psychology.* Sherrington: *The Integration of the Nervous System.* Thorndike: *Elements of Psychology.*

CHAPTER VII.

THE END ORGANS AND SENSATION.

Sensation. In order that I may hear the watch which lies before me on the table, several concomitant factors are necessary. In the first place the air must vibrate so that waves of sound may beat upon my ear drums. Secondly, the mechanism of my ear must be perfect. Thirdly, the auditory nerve connecting my auditory mechanism with the central nervous system must be intact and undiseased. And lastly, that part of my cerebral cortex concerned with hearing must be in active working order. If any part of the chain is missing or defective, no sound is heard, although the remaining parts are in perfect condition. For example, remove the air by placing the watch under the bell-jar of an air-pump. The sound becomes fainter as the air is removed and eventually ceases. Stop up my ears with wax, or puncture my ear drum, or displace the ossicles (see later) of the middle ear and each will be found effective as a means of destroying the sound so far as I am concerned. Injure my temporal lobe and though the vibrations of the watch are transmitted as physical and nervous stimuli right up to the cortex, no sound is heard. If, however, the chain is complete, the sound is heard. I, of course, hear it as the sound of a watch and not as the sound of a church bell or a human voice, but if one can think of me hearing it simply *as sound* without reference to any previous experience, I should get a *sensation* of sound.

A sensation then is the simple consciousness aroused by the transmission of nervous energy from a receptor or sense organ to some part of the cerebral cortex. Before such transmission can take place the sense organ must be stimulated. In their evolution sense organs became modified according to the energies of the physical world.

The ear, as we have seen, is now adapted to receive air waves of sound, the eye is affected by extremely rapid vibrations of ether; while some of the receptors are sensitive to slower vibrations of ether known as radiant heat.

But such a simple mental process as a sensation, owing to the complex nature of the cerebral cortex, is never experienced in ordinary life. Other forms of consciousness are aroused concomitantly, but the basis of all knowledge is the simple sensation—that fiction of psycho-physical science.

Sensation arises as the result of the excitation of a sense organ. We are accustomed to speak of the five senses or of the "five gateways of knowledge" (Milton). Modern investigation, however, has shown that fifty is nearer the mark than five. For example, we now recognise organic sensations such as thirst, headache, fatigue and nausea which are due to the state of the internal organs; and kinaesthetic sensations due to the varying states of muscles, tendons and joints. It is customary, however, to classify sensations according to the sense organs through which they come.

Attributes of Sensations. Sensations are usually deemed to possess the following characters—quality, intensity, protensity and extensity. These will best be understood from examples, for they are extremely difficult to define. By *quality* is meant the aspect of sensation which enables the distinction to be made between different colours, different tones, different tastes and so forth. The quality of light sensations depends almost wholly upon the wave length of the excitatory rays. Blue rays have a shorter wave length than red rays. Quality, then, makes one sensation different from another. By *intensity* we mean a peculiar kind of quantity (strength) of sensation. Colours differ in brightness while maintaining the same colour-tone (*i.e.* colour-quality other than that which is constituted by degrees of paleness or darkness), cold may be more or less cold, sour may be more or less sour and so on. These are different intensities of sensations. The sensation is practically the same *kind* of sensation only there seem different strengths of it, as it were. By *protensity* is meant the aspect by means of which we experience a difference between sensations because of their duration. Protensity cannot be measured by a clock, for it is not a physical thing, but we all know that a prolonged shriek is different from a short shriek and chiefly because of its duration. By *extensity* we understand that character of sensations which enables us to perceive, for example, differences between a square centimetre of pink paper and a square yard of the same substance. It should be noticed that intensity, protensity and extensity of sensation correspond to energy, time and space of physical science.

The Weber-Fechner Law. The character of sensation known as intensity is interesting from a scientific point of view because the stimuli which produce different intensities lend themselves to measurement fairly easily. Innumerable experiments have been made to determine the upper and lower limits of intensities of sensation (such, for example, as the highest and lowest pitch, the limits of the spectrum, etc.), and to discover the relationship existing between changes of intensity of sensation and changes of intensity of stimuli. Weber was the first to work upon the second problem. He tried to determine, by the method of least noticeable differences, the ability of the skin and "muscle-senses" (those which make us aware of the position and movements of our limbs, tension of our muscles, etc.), to discriminate weights. He found that a weight of 30 half-ounces could just be distinguished from one of 29 half-ounces, and that, when working with drams, 30 drams could just be distinguished from 29 drams. The least noticeable difference, therefore, varied with the stimulus and was not a fixed quantity. Experiments with other senses showed that the generalisation was fairly true although different fractions were obtained. He therefore stated that the least noticeable difference, in each kind of sense-perception, is a constant fraction of the stimulus. Fechner tested this generalisation and modified it to the following: to make sensation increase in arithmetical progression, the stimulus must increase in geometrical progression, or, in a neater phrase, sensation is proportional in strength to the logarithm of the stimulus.[1] The following diagram (from Howell's *Text-Book of Physiology* (p. 269) illustrates the Weber-Fechner Law:

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[1] For an excellent criticism of the Weber-Fechner Law, see Myers: *Text-Book of Experimental Psychology*; Chap. XIX.

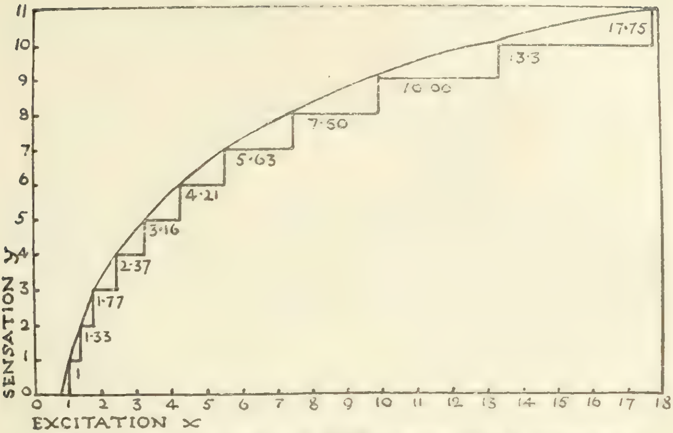

FIG. 21. Curve to indicate the Weber-Fechner law of a logarithmical relation between excitation and sensation (from Waller). The excitations are indicated along the abscissae, the sensations along the ordinates. The increase in sensation is represented as taking place in equal steps, "the minimal perceptible difference," while the corresponding excitations require an increasing increment of ⅓ at each step, namely 1, 1·33, 1·77, 2·37, etc. That is, for equal increments of sensation increasing increments of stimulation are necessary.

That there is much truth in Weber's generalisation all will be ready to admit. A pin is easily heard to drop if the room is quiet, but the noise of a cracker is hardly noticed at a scholars' noisy Christmas party. A candle makes a great difference to a badly lighted room, but 40 candles make no appreciable difference to a small room lighted by an electric arc lamp or by brilliant sunlight. One potato added to the weight of a sack of potatoes is not perceived, while one potato added to a small bag of potatoes makes an appreciable difference. But too much importance must not be attached to the exact mathematical relationship. It is fairly true for most sensations in the centre of the scale of intensity, but only approximately true for sensations near their extreme limits. For differences in weight it is far from exact even in the centre of the scale. Cattell's modification, namely, that the just perceptible differences increase according to the square root of the stimulus is more true to experimental fact.

According to Wundt, the figures which express the constant ratio between increase of stimulus and increase of intensity of sensation for several senses are as follows:[1]

Sensation of light	$\frac{1}{100}$
Muscular sensation	$\frac{1}{17}$
Feeling of pressure	$\frac{1}{3}$
,, warmth	$\frac{1}{3}$
,, sound	$\frac{1}{3}$

The Eye and Sensation of Sight. It is estimated that eight-tenths to nine-tenths of our total experiences are obtained by means of vision, while it is certain that the eyes of modern man are suffering rapid deterioration. Hence it may be profitable to devote a few paragraphs to the discussion of vision.

The eye, as we all know, is a spherical body placed in the cavity of the head. This cavity, however, is not spherical but conical in shape in order to accommodate the muscles of the eye. The space not filled up by the eye-ball, muscles and lachrymal gland, is occupied by fatty tissue which forms a cushion on which the eye-ball rolls easily. The eye is furnished with six muscles—four *recti* or straight muscles, and two *oblique* muscles—superior and inferior. These muscles, singly or in various combinations, turn the eye upon four axes of rotation and cause the characteristic movements of the eye.

If the eye is removed from the socket, it is seen that the outer coat is composed of two parts—the white of the eye, known as the *sclerotic*, and a protuberant transparent part known as the *cornea*. Beneath the sclerotic is another coat known as the *choroid* coat. This membrane contains numerous blood-vessels which, however, are hidden in normal eyes by black pigment cells. If a person is defective in pigment he has the "pink-eye" of the albino. This choroid coat corresponds to the dead-black lining of a camera. Within the choroid, but not quite co-extensive with it, is the inner coating of the eye. This is the delicately sensitive *retina* upon which the visual images are thrown.

The contents of the eye-ball are equally interesting. The choroid coat at the ring of junction of the cornea and sclerotic, changes its character and forms the coloured part of the eye known as the *iris*. The iris, with the exception of a communicating hole known as the *pupil*, divides the eye into two chambers. The anterior chamber in front of the iris is filled with a watery substance known as the *aqueous humour*, while the posterior chamber is filled with the *crystalline lens* and its *ciliary muscle*, and a transparent

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[1] James: *Psychology*; I., 537.

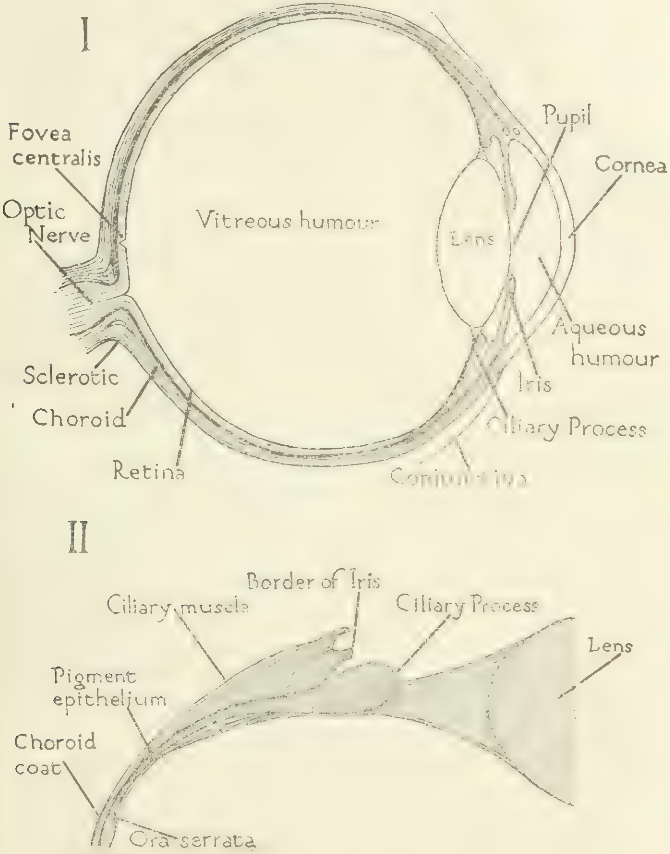

FIG. 22. I. Horizontal section through the left eye (schematic after Gegenbaur). II. Meridional section to show the position of the ciliary muscle (Schultze).

jelly-like substance known as the *vitreous humour*. The iris is composed of two sets of contractile tissue—radiating and circular—which enable the pupil to be enlarged or decreased according to the brilliance of the light. The lens is composed of fine yet transparent and elastic material of moderate optical density (index of refraction is 1·39 at edge, 1·41 in centre). It is enclosed by a transparent membrane, known as the *capsule*, which is attached to the circular ciliary muscle fastened to the ciliary process. The contraction of the ciliary muscle pulls the capsule towards the front of the eye, that is, towards a decreasing section of the eye. The consequence of this tension on the capsule is a relaxation of the lens, which therefore swells and becomes more convex. The eye then becomes "accommodated" for near objects.

The retina is a specialised continuation of the optic nerve, which pierces the sclerotic and choroid coats of the eye and spreads its fibres over the interior surface of the eye-ball. These fibres turn their ends outwards towards the sclerotic and change their character, becoming first granules and nucleated cells, and afterwards the sensitive (bacillary) layer of the retina known as *rods* and *cones*. In order that light may excite the rods and cones it must first pass through a layer of nerves, granules and nucleated cells. From this it follows that the nerves themselves are probably insensitive to light. That this is really so is proved by the existence of the "*blind spot*" (lacuna) where the optic nerve enters the eye. At one point of the retina—*fovea centralis*, which is a depression in the *macula lutea* (yellow spot)—cones only are found, and this part of the eye, which is exactly behind the pupil, is especially sensitive to light. There are probably no less than a million cones to a square tenth of an inch in this spot. The manner in which an image is thrown on the retina can be understood from any elementary treatise on light. It may, however, be noticed that the eye acts in a manner very similar to a photographic camera, except in the method of focussing.

The rods and cones act differently towards light. The rods are far more sensitive to light and darkness than the cones and hence in daylight are in a constant state of fatigue. They possess a red pigment which is bleached by light, known as *visual purple* or *rhodopsin*. If we pass from a brilliantly lighted room into a dimly lighted one, we are at first unable to see anything because the light is too feeble to excite the cones and the visual purple of the rods is exhausted. In a short time the rods recover and we are able to perceive the shapes of objects within the room, but there are no colours visible ; everything appears in various shades of grey. From this we may conclude that the rods are insensitive to colour.

The questions of binocular vision and after-images are too complicated for discussion in the brief space at our disposal. Defects of the eye were treated briefly in Chapter IV.

Colour vision is, however, so important in school-life that a brief description of the various theories will now be attempted. The colours of the spectrum are probably those best known by mankind, though only one person in three thousand is able to distinguish indigo in the spectrum.[1] These colours are not simple, but are fusions of certain so-called primary colours. The primary colours, according to Clerk Maxwell, are red, green and violet (which he called blue). How shall we explain colour vision ? Three main theories have been propounded, namely, the Young-Helmholtz, the Hering and the Franklin Theories.

The *Young-Helmholtz* theory, proposed by Thomas Young (1809) and modified and expanded by Helmholtz, rests upon the assumption that there are three photochemical substances in the retina corresponding to the three fundamental colours—red, green and violet. Decomposition of these substances causes impulses to be carried to the cortical centre of sight and corresponding colours are perceived. When all three substances are equally stimulated white is produced, just as it is produced by mixing the three primary colours. Black results from the absence of such stimulation. All other colour sensations are produced by stimulation of different proportions of the photochemical substances in combination. The weaknesses of the theory are almost self-evident. We are certainly not conscious that white, yellow and orange are compounded colour sensations. Nor does it explain why the edge of the retina is colour-blind and yet perceives whites, blacks and greys. And in the perception of black, why should the central nervous system be active while the eye is inactive ? Lastly, it is anti-evolutionary, for, in the history of the race, whites and greys are seen before colours.

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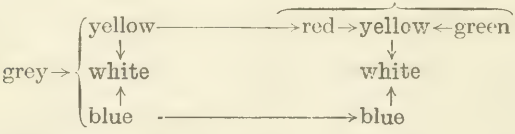
[1] Edridge-Green : *Colour-Blindness* ; p. 103.

The *Hering* theory also assumes three photochemical substances or receptors, but these are capable of giving six fundamental sensations. The photochemical substances are the white-black, the red-green and the yellow-blue. During dissimilation or katabolism by the action of light, white, red, and yellow sensations are produced. When undergoing recovery from light, *i.e.* when assimilation or anabolism is taking place, black, green and blue are the sensations which are obtained. Hering's red must be slightly purplish and his green slightly bluish in order that they may be exactly complementary and therefore antagonistic. The theory certainly explains most of the facts of colour vision, but what the processes of assimilation and dissimilation really are, Hering does not explain. He simply needs two opposed and neutralising effects.

The *Franklin* theory has the advantage of being an evolutionary one. It supposes that the eye in earlier times could only perceive blacks, whites and greys. There was in fact only one "grey substance." As the eye evolved, this grey substance became sensitive to vibrations of other wave lengths—first yellow, and then blue. This stage of evolution is still found on portions of the periphery of the retina. This "yellow substance" again develops and becomes sensitive to red and green. If the red and green are both acted upon it is just as if the original yellow was affected. Blue still remains undeveloped. The scheme is as follows:



The primitive grey substance first differentiates into a yellow- and a blue-perceiving substance which in combination give white. The "yellow substance" has differentiated still further into a red- and a green-substance. These in combination give yellow.

This theory, while explaining the normal phenomena of vision, is especially useful for explaining the facts of colour-blindness and the variations in quality of our visual sensations in the peripheral areas of the retina.[1]

The Ear and Sensations of Sound. The parts of the ear will perhaps be best understood by means of the following diagram :

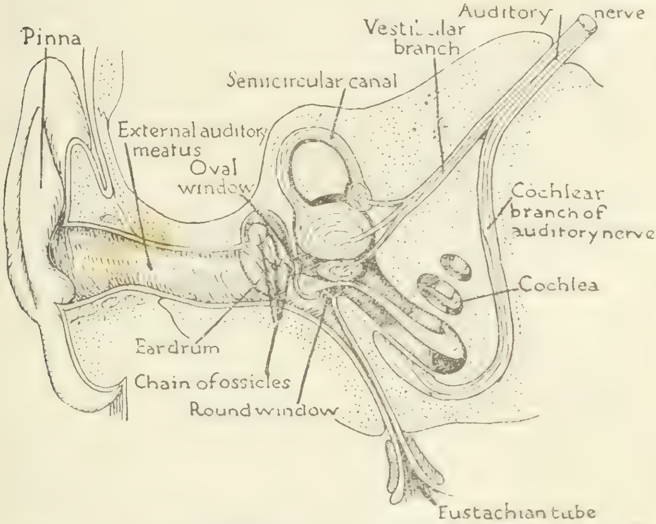


FIG. 23. Semi-diagrammatic section through right ear (after Czermak).

There are three main parts, namely, the external ear, the middle ear and the inner ear. The external ear is composed of the *pinna* (the "ear" of the layman), the *external auditory meatus* (the " ear-hole "), and the *tympanic membrane* or ear-drum. The middle ear is a cavity which is connected to the outside world by means of the *Eustachian* tube, the throat and the mouth. It has a chain of bones or *ossicles* connecting the drum to the inner ear. These bones, from their shapes, are known as the *malleus* (hammer), *incus* (anvil) and the *stapes* (stirrup). The hammer is attached to the tympanic membrane: the foot-piece of the stirrup fits the *fenestra ovalis* (oval-window) of the vestibule of the inner ear. The inner ear, or *labyrinth*, is composed of three parts—the *vestibule*, the three *semi-circular canals* and the spiral-shaped *cochlea*. The vestibule is the central part of the inner ear. It is connected with the semi-circular canals on the one hand and the cochlea on the other. The semi-circular canals are arranged in the three dimensions of space and are the organs of equilibration. The cochlea is the organ of hearing. It is embedded in bone and consists of a spiral of 2½ turns resembling in shape the shell of a snail. The spiral is divided into three passages or canals by means of *Reissner's membrane*, and by the bony *lamina spiralis* with its continuation—the *basilar membrane*. The three passages are called the *scala vestibuli* (because it opens into the vestibule), the *cochlear canal*, and the *scala tympani*, which is separated from the middle ear (tympanic cavity) by the round window (*fenestra rotunda*). The vibrations of the ossicles pass from the oval to the round window by means of the passages of the cochlea. These mechanical vibrations are converted into nerve impulses chiefly by means of the basilar membrane and the *organ of Corti*. The organ of Corti is attached to the basilar membrane and is composed, in part, of cells, to which short hairs are attached. Around these cells the terminal arborisations of the cochlea nerve fibres end and so we may be sure that the hair cells are the instruments for conversion of physical into nervous stimuli.

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[1] None of the theories is absolutely satisfactory. If some person skilled in making microscopical sections would only work on those of the retina, perhaps some difference of structure in the rods and cones of different parts of the eye would be revealed. It is difficult to conceive differences of function without corresponding differences of structure. The task would be difficult because the sclerotic, which would have to be sectioned at the same time, is one of the toughest membranes of the body.

Many theories of this conversion have been put forward. Helmholtz[1] thought it was due to resonance or sympathetic vibration of the fibres of the basilar membrane, but the explanation is now known to be unsatisfactory because of the discovery of radial fibres in this organ. Ewald,[2] after experimenting with a model of the basilar membrane, came to the conclusion that fixed vibration figures were produced by each sound the components of which could be analysed. The vibrations of a given rate would cause the basilar membrane to vibrate in certain places—not simply in one place, as the Helmholtz theory suggests—and the corresponding parts of the sensory apparatus would be excited by each vibration rate. Combinations of nerve fibres would be excited by a single tone. This conception is more difficult than that of Helmholtz, yet it is probably nearer the truth. But no theory is as yet quite satisfactory. The impulses, however started, are transmitted to the brain by the cochlear branch of the auditory nerve. The other branch of this nerve, the vestibular branch, runs to the canals and vestibule and is concerned with equilibration.

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[1] Helmholtz: *Die Lehre von den Tonempfindungen*; 1895, tr. by Ellis as *Sensations of Tone*.

[2] Ewald: *Pflüger's Archiv f. d. gesammte Physiologie*; 1899 and 1903.

The ear gives sensations of noise and sensations of tone. A noise is harsh and due to aperiodic vibrations. A tone is smooth and is due to periodic vibrations. Most sounds are combinations of noises and tones. The human ear and brain distinguish about 11,000 tones, but music utilises only 90 of these. Some tones, separated from each other by an interval of an octave, are more similar than others. The same note sounded by different musical instruments sounds different because of differences of noises and overtones. A high tone has a shorter wave length than a lower tone. A loud tone has vibrations of greater amplitude than a softer tone. Loudness or intensity, pitch, phase, and timbre are the properties of musical sounds which affect the vibrations of the ear-drum.

The Skin and Cutaneous Sensations. The skin is not merely a sense-organ like the eye or the ear; it has protective and other functions. It has within it at least four different kinds of sense organs. There are receptors for *pressure, heat, cold* and *pain.* These receptors are exceedingly numerous and are dotted in haphazard fashion over the surface of the body. The punctiform distribution of any one type of receptor is not uniform; there are places where they are crowded together. Thus the tip of the tongue, the lips, and the ends of the fingers are specially sensitive to pressure; the tip of the tongue and the eyelids to heat and cold; and the membranes of the eye to pain.

Pain spots may be discovered by "exploring" a portion of the skin with a stiff bristle or a needle. Some parts will be found to be far more sensitive to pain than others. Immediately beneath these parts are the receptors for pain. If a fine hair be used instead of a needle, spots which are sensitive to light pressures may be discovered. On hairy parts of the skin a "touch or pressure spot" is found over each hair root. Cold spots may be demonstrated by exploring with a cold bluntly pointed metal rod, and warm spots by means of a metal rod warmed to about 45° C. Warm spots are the least numerous and pain spots by far the most numerous and most variable of the cutaneous sense-spots. The specific energy of the cutaneous nerves (see Chap. VI.) may be demonstrated by touching a cold spot with a warm rod, when a sensation of cold and not warmth is aroused. It should be noticed, however, that intense stimulation of any spot probably causes pain.

If a cutaneous nerve is severed, the skin it supplies becomes completely anaesthetic. Strong pressures and movements may still be felt, but it is by means of sensory fibres to the underlying muscles. This is the "deep sensibility" discovered by Head and Rivers.[1] As the nerve heals, sensitivity of the skin returns, but in a somewhat peculiar way. There seem to be two systems of sensory fibres which regenerate at different times. The first system conveys sensations of a diffuse, low, imperfectly localised kind such as extremes of heat and cold (above 37° C. and below 26° C.), and pain. This is called *protopathic* sensitivity since it seems to be of vital importance to the life of the organism. The second system of fibres, which regenerate more slowly than those concerned with protopathic sensitivity, is sensitive to moderate temperatures (26°-37° C.) and to light pressures. Unlike sensations of the protopathic kind, these are perfectly localised. This is called the *epicritic* system of cutaneous sensibility. It is probable that the epicritic system is the more recently evolved since it is the last to be regained.[2] The epicritic system also is probably instrumental in enabling us to recognise the size and shape of objects.

The Nose and Mouth and Sensations of Taste and Smell. In addition to pressure, heat, cold and pain, the mouth (aided by the nose) gives us four sensations of taste—*sweet*, *bitter*, *sour* and *salt*. The ends of the nerve fibres of taste, localised chiefly in the tongue, are roughly oval in shape. They lie at the base of the large *circumvallate*

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[1] Head and Rivers: *A Human Experiment in Nerve Division*; Brain, 1908, XXXI., 323-460. See also Brain, 1905, p. 99.

[2] For a description and discussion of Head and Rivers' work see Myers' *Introduction to Experimental Psychology*; Chapter I., 1911.

papillae and some of the *fungiform papillae* (the small 'pimples' of the tongue). The action is chemical, since insoluble matter is invariably tasteless. The "feeling" of food (oily or astringent, for example) and the smell of it (aroma of coffee, for example), are instrumental in aiding taste. If the nose be closed, the eyes shut and food made into a pulp before being placed on the tongue, it is impossible to tell the difference between onion and apple, or coffee and quinine. Bitter tastes are best tasted at the back of the tongue, sweet tastes at the tip, sour and salt tastes at intermediate areas. It is probable that the specific energies of the nerves (*supra*) hold for taste.

The end organs for smell are confined to the upper nasal cavity and, according to von Brunn, to the *nasal septum* and the upper *turbinate* bone. The fibres connecting these to the brain through fine holes in the base of the skull are the shortest in the body. In order that we may smell, the air must diffuse or pass up as currents into the nasal chamber. The classification of smells is exceedingly difficult. The best, perhaps, is that of Zwaardemaker, which is as follows :

1. Ethereal odours, including the odours of fruits which depend for their smell upon ethereal esters.
2. Aromatic odours—camphor, citron, bitter almond, resinous bodies, etc.
3. Fragrant odours, comprising the scent of flowers, vanilla, tea and balsam.
4. Ambrosial odours typified by musk and amber.
5. Alliaceous or garlic odours such are found in the onion, india-rubber, sulphur compounds and the halogens.
6. Empyreumatic or burnt odours, including burnt foods, tar, phenol, tobacco smoke and roasted coffee.
7. Hircine or goaty odours. The odour of goat is due to caprylic acid in the sweat. These odours include cheese and rancid butter.
8. Repulsive odours, as of some insects and certain narcotic plants.
9. Nauseous or foetid odours, as of decaying flesh and organic matter.

Both taste and smell are extremely sensitive. It is usually stated that ·00005 grms. of quinine dissolved in 100 cc. of water can be detected on the root of the tongue, and sugar to the extent of ·5 grms. in 100 cc. of water can be tasted on the tip of the tongue. Smell is even more sensitive. Musk, 1 part to 8,000,000, and mercaptan $\frac{1}{460000000}$ milligram in 50 cc. of air, are perceptible. The threshold of smell for dogs is beyond computation.

Smell (and taste ?) is probably decadent in man. Both smell and taste tend to be associated in modern life with over-indulgence and over-gratification of bodily appetites.

Development of Sensory Powers in Children. A child at birth is almost deaf and, to all intents and purposes, is smell-less, sight-less and taste-less. The sensory powers are of gradual development, and the problem of tracing their growth is one of extreme difficulty. When does a child begin to discriminate between colours ? between smells ? and between musical tones ? When do perceptions of space and of time arise ? Yet answers to these questions are of extreme importance to education. From the researches of Preyer, Baldwin, Myers, McDougall, Miss Tucker and others we are led to the conclusion that brightness is perceived at about 5 or 6 months and that this is immediately followed by discrimination of reds and yellows from all other colours. With older children discrimination of blues present more difficulty than reds and yellows. Sound perception is not highly developed when children reach school age. Only $\frac{1}{5}$ of the children entering school can sing a song from memory and only $\frac{2}{5}$ can sing a melody after it has been sung to them. The greater percentage of deafness among younger children is probably due to their inability to discriminate between sounds. Judgment of distance with the eye is non-existent in young babies (they grasp at the moon), but by the time 7 or 8 years of age is reached, it is probably as accurate as in adults. The ability to appreciate time is of extremely slow development. "Once upon a time" is the child's notion of the past, and uneducated adults are probably not much more advanced. The Montessori system of education, whatever its faults, is extremely valuable, inasmuch as it insists upon the separate and systematic training of the sensory powers. Such training in the past has either been neglected altogether, or given in a haphazard fashion.

References. Angell : *Psychology* ; Chap. V. Betts : *The Mind and its Education* ; Chaps. IV., VI. Drummond :

The Child: Chap. VI. Howell: *Elements of Physiology.* James: *Psychology, Briefer Course*; Chaps. XV., XXI. James: *Text-Book of Psychology*; Chaps. II.-VI., and XX. Judd: *Psychology*; Chap. V. Ladd and Woodworth: *Elements of Physiological Psychology.* McDougall: *Physiological Psychology*; Chap. IV. Myers: *Introduction to Experimental Psychology*; Chaps. I. and III. Myers: *Text-Book of Experimental Psychology*; Chaps. II.-IX., XV.-XXIII. (contains a valuable Bibliography). Rusk: *Experimental Education.* Seashore: *Elementary Experiments on Psychology*; Chaps. I., II., III., V., VII. Stout: *Groundwork of Psychology*: Chaps. IV. and V. Titchener: *Primer of Psychology*; Chap. III. Thorndike: *Elements of Psychology*; Chap. II. Thorndike: *Notes on Child Study*; Chap. VII. Whipple: *Manual of Mental and Physical Tests*; Chap. VI.

SECTION III.

DYNAMIC OR FUNCTIONAL PSYCHOLOGY.

CHAPTER VIII.

INSTINCTS AND CAPACITIES.

Definition of Instinct. We have seen from our studies of the finer structure of the nervous system that certain connections of neurones are made in the normal course of growth, without the intervention of external stimuli. The sympathetic system at birth has become definitely connected with the blood-vessels and other organs over which it exercises control. Consequently the physiological functions of breathing, perspiring, digesting and so forth are natural from birth and need no learning. In exactly the same way connections are established between groups of sensory neurones, which run to the periphery, and corresponding groups of motor neurones, which are united to muscles lying in related areas. In consequence of this second type of innate connection a baby can wink, snuffle, sigh, sob, cough, snore, vomit, withdraw the hand when it is pricked, withdraw the foot when the sole is tickled, all without being taught. But there is a third type of reaction which is just as much unlearned as the physiological functions of breathing and digesting or the so-called reflexes of coughing and winking. When appropriate stimuli are given, a child walks, is acquisitive, curious or pugnacious according to the type of stimuli given. Such unlearned reactions are known as *instincts*. They are easily distinguished from *innate physiological* functions, but the line of demarcation between them and *reflexes* is not so easily drawn. Herbert Spencer looked upon instincts as compound reflex actions, and there is much to be said for this point of view. All that we can say at present is that, in general, instincts are more complex than reflexes and that they are attended with greater degrees of consciousness.

As a definition we may accept that of Lloyd Morgan,[1] who states that instinctive behaviour comprises "those complex groups of co-ordinated acts which are, on their first occurrence, independent of experience; which tend to the well-being of the individual and the preservation of the race; which are due to the co-operation of external and internal stimuli; which are similarly performed by all the members of the same more or less restricted group of animals; but which are subject to variation and to subsequent modification under the guidance of experience."

Instincts and Capacities. Capacities are those native abilities which are of the same nature as instincts but are somewhat vaguer in character. We talk about an instinct of fear, but capacity is the term we use when we speak of rote-memorising, music, leadership, drawing, management of ideas and the like. We could, however, interchange the terms and talk about a capacity for fear and an instinct for language. Custom alone dictates the use of the two terms. A capacity needs a more highly developed stimulus than does an instinct to stir it into action. Capacities are also more variable than instincts. Instincts as a rule appear earlier in life than capacities and pass away more rapidly unless hardened into habits.

The Number of Instincts and Capacities. Earlier psychologists [2] were prone to think that, whereas the instincts of animals were exceedingly numerous, those of children were comparatively few in number. The error arose from the fact that the life of animals is largely a life of instinct while that of a man is so complex as to hide its fundamental instinctive basis. The following lists [3] of instincts and capacities of man prove that they are far indeed from being few in number.

INSTINCTS (those marked D are doubtful).

1. Sucking.
2. Biting an object placed in the mouth.

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[1] *Animal Behaviour*; p. 71.

[2] For example, Preyer in *The Mind of the Child.*

[3] From Thorndike: *Notes on Child Study*; Chap. V., and Thorndike: *Principles of Teaching*; Chap. III.

3. Chewing and grinding the teeth.
4. Licking.
5. Making characteristic grimaces, over bitter and sweet tastes.
6. Spitting.
7. Clasping things which the palm of the hand touches.
8. Grasping at certain objects, *e.g.* small, bright, or moving objects.
9. Carrying to the mouth the object when grasped.
10. Pointing.
11. Making a peculiar sound expressive of desire.
12. Crying.
13. Protrusion and puckering of the lips.
14. Turning the head aside.
15. Holding head erect.
16. Sitting up.
17. Standing.
18. Creeping.
19. Walking.
20. D. Following objects which are going away slowly.
21. Retrieving; that is, getting an object and bringing it back.
22. D. Running from objects which are coming towards the child quickly.
23. Climbing.
24. Vocalisation; that is, the general babbling of infants.
25. Emulation or rivalry; that is, the tendency to do what others are doing in such a way as to get what they get.
26. Pugnacity and mastery.
27. Resentment.
28. D. Sympathy.
29. Hunting; that is, the tendency to catch, play with, and tease small living things.
30. General physical activity including manipulation; that is, the general tendency to move in all sorts of ways, not to keep still, to do things to things, to avoid bodily torpor.
31. General mental activity; that is, fondness for having ideas, pleasure at the presence of feelings or thoughts, delight in mere thinking irrespective of the consequences.
32. Fear of noises.
33. Fear of strange men and animals.
34. Fear of black things.
35. Fear of the dark.
36. Fear of open places.
37. Fear of high places.
38. D. Fear of spiders and other vermin.

39. Fear of snakes.
40. D. Fear of solitude or sociability.
41. Acquisitiveness; that is, the tendency to take what one sees.
42. Miserliness or ownership; that is, the tendency to keep what one takes, to resist attempts to take away anything one has had about him.
43. Unreasoning collecting and hoarding of objects.
44. Fear of exposure; that is, the tendency to feel comfortable and to repose when sheltered.
45. D. Cave dwelling.
46. Play.
47. D. Constructiveness.
48. Curiosity.
49. Secretiveness.
50. D. Cleanliness.
51. D. Modesty.
52. D. Shame.
53. Love.
54. Jealousy.
55. Kindliness.
56. Independence and Defiance.

Capacities.

A. Fundamental Capacities:
   1. Impression, the capacities for sensitivity of the different sense organs.
   2. Expression, the capacities for arousing movement of the different motor organs.
   3. Connection, the capacity to form habits.
   4. Selection, the capacity to maintain and strengthen one mental process in preference to others.
   5. Analysis, the capacity to break up a fact into elements, to think of and react to parts and aspects.

B. Special capacities which are either sub-divisions of fundamental capacities or complexes of different capacities.
   1. The management of things.
   2. ,, ,, ,, men.
   3. ,, ,, ,, concrete ideas.
   4. ,, ,, ,, abstract ideas and symbols.
   5. Self-control.
   6. Energy.
   7. Precision.
   8. Thoroughness.
   9. Originality.
   10. Co-operation.

11. Leadership.
12. Self-denial.
13. Self-reliance.
14. Refinement.
15. Sympathy.
16. Rote-memorising.
17. Observation.
18. Various complex capacities connected with school work such as drawing, music, mathematical reasoning, language and others almost too numerous to mention.

Attributes of Instincts. At birth a child can suck, and can grasp with both fingers and toes, but he cannot walk, climb, play, or feel attracted by the society of the opposite sex. Yet we say that instincts are innate. So they are, but this does not mean that all are perfect at birth. They develop slowly in fairly regular sequence and always in conjunction with the muscles which enable the instinctive act to be performed. It is useless to dangle the feet of a two months' old child on the ground in the hope of stimulating the instinct of walking, simply because the muscles of the leg and back and the nervous system controlling them are insufficiently developed at this age. Yet a similar procedure a year later will probably be effective. We must, however, await nature's time.

Instincts are transitory, they are not given for all time. Spalding[1] has shown that chickens when born have an instinct or tendency to follow. They follow most naturally the mother hen, but, if she is absent, they will follow a man, a cat or a dog. Three or four days later the instinct of fear develops. If, therefore, the following instinct is inhibited by covering the heads of the chicks with hoods for three or four days, the instinct of fear will cause them to run and hide. Spalding describes their behaviour as follows :

> " Each of them, on being unhooded, evinced the greatest terror to me, dashing off in the opposite direction whenever I sought to approach it. The table on which they were unhooded stood before a window, and each in its turn beat against the window like a wild bird. One of them darted behind some books, and, squeezing itself into a corner, remained cowering for a length of time. We might guess at the meaning of this

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[1] Spalding: *Macmillan's Magazine*; Feb. 1873, pp. 287-9. Quoted by James, II., p. 396.

strange and exceptional wildness: but the odd fact is enough for my present purpose. Whatever might have been the meaning of this marked change in their mental constitution—had they been unhooded on the previous day, they would have run to me instead of from me—it could not have been the effect of experience; it must have resulted wholly from changes in their own organisations."

After four days it is practically impossible to get chicks to follow: the optimal time has passed and the instinct has faded away.

Another remarkable instance of the transitoriness of instinct is given by Francis Ward,[1] but in this case the instinct was wooed back. An otter was kept from babyhood in a rabbit hutch, and at the age of two years had never been in water. She was then placed on the banks of an observation pond which contained two dozen $\frac{1}{4}$-lb. trout. The instinct to fish had passed, for not only did the otter fail to fish for herself but she also showed the utmost aversion to water. Starvation for three days failed to make her catch a trout, and only by placing food further and further down a sloping shingle beach was she induced to enter the water. Still she did not swim. She first swam by jumping into the water when surprised by the owner. After this she would dive for food. Soon afterwards a number of $\frac{1}{4}$-lb. roach were introduced into the pond and these aroused the latent instinct of fishing. From this time onwards all fear of the water disappeared and she became a normal otter. There seems to be no doubt that even such a strong instinct as fishing, which is necessary to the life of the otter in its wild state, had almost faded away. The treatment undertaken with the otter coaxed the instinct back to life.

Children may, in the same way, have instincts which gradually fade away. Practically all children are born with a capacity for oral language, but if, through deafness, a child does not learn to speak before the age of four or five years, the capacity rapidly disappears. Teachers of the deaf are unanimous in saying that seven years of age, the normal age of entry into schools for the deaf, is much too late if adequate progress in speech is to be made. Infinitely better results are obtained when children are introduced to the school at three or even as early as two years of age.

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[1] *Teaching an otter to take to water*: Country Life, March 23rd, 1912.

The reason is that the capacity for language has its optimal time between the ages of one and four years and, if advantage is not taken of it, the power gradually fades away. It is practically impossible to teach a deaf boy of more than ten years of age to speak.

City children again are often denied the joys of climbing, especially climbing trees, because there are no opportunities for the exercise of the instinct when it duly makes its appearance, sometime between the ages of four and six years.

So we are led to the important conclusion that we must await the optimal times for desirable instincts and then give them as much exercise as is humanly possible. For example, curiosity about the mechanism of the human body does not awaken before adolescence, hence it is worse than useless to try to teach physiology to ten-year-old children. But physiology to fifteen-year-olds is one of the most fascinating subjects of the curriculum.

Instincts harden into habits. The reason why instincts, such as were enumerated in the preceding paragraphs, apparently do not disappear is that they are conserved as habits. Although a child, who had never walked before reaching the age of four, would have great difficulty in learning, a normal child learns to walk between the ages of one and two and thereafter retains the power of walking as a permanent possession. The instinct of walking has disappeared but the habit of walking is retained as its substitute. The same line of reasoning applies to drawing, music, language, rote-memorising, leadership, curiosity and so forth. These instincts and capacities undoubtedly fade away if not hardened into habits, and it is greatly to be feared that many schools are open to blame for deliberately killing off such desirable capacities as originality, self-reliance and leadership.

Instincts are indefinite, variable and may be transferred. The definiteness and invariability of instincts were favourite themes of the earlier animal psychologists. But some of their statements have been controverted as a result of more careful observation or experiment. Thus we find that Lloyd Morgan[1] makes the following observations :

> " Romanes thought that the manner of stinging (by solitary wasps) and paralyzing their prey might ' be justly deemed the most remarkable instinct in the world.' Spiders, insects, and

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[1] *Animal Behaviour* ; p. 73.

caterpillars are stung, he says, 'in their chief nerve-centres, in consequence of which the victims are not killed outright, but rendered motionless; they are then conveyed to a burrow and continuing to live in their paralyzed condition for several weeks, are then available as food for the larvae when these are hatched. Of course the extraordinary fact which stands to be explained is that of the precise anatomical, not to say also physiological knowledge which appears to be displayed by the insect in stinging only the nerve-centres of its prey.' Eimer thought that it 'is absolutely impossible that the animal has arrived at its habit otherwise than by reflection upon the facts of experience.' 'At the beginning,' he says, 'she probably killed larvae by stinging them anywhere, and then placed them in the cell. The bad results of this showed themselves; the larvae putrified before they could serve as food for the larval wasps. In the mean time the mother wasp discovered that those larvae which she had stung in particular parts of the body were motionless but still alive, and then she concluded that larvae stung in this particular way could be kept for a longer time unchanged as living motionless food.'

"Now, since these wasps, when they have stored their nests and laid an egg on one of the victims, close it up at once and for all, and take no further interest in it or its contents, there seem no opportunities, at any rate in the existing state of matters, for the acquisition of that experience on which Eimer relied, but both his explanation and Romanes's difficulty are based on the following assumptions: first, that the victims are instinctively or habitually stung in the chief nerve-centres; secondly, that when thus stung they are not killed but remain paralyzed for weeks; and thirdly, that the marvellously definite and delicate instinctive behaviour is in direct relation to the uniform result of prolonged paralysis and consequent preservation of the food in the fresh state. But Dr. Peckham's careful observations and experiments show that, with the American wasps, the victims stored in the nests are quite as often dead as alive, that those which are only paralyzed live for a varying number of days, some more, some less, that wasp larvae thrive just as well on dead victims, sometimes dried-up, sometimes undergoing decomposition, as on living and paralyzed prey, that the nerve centres are not stung with the supposed uniformity; and that in some cases paralysis, in others death, follows when the victims are stung in parts far removed from any nerve centre. 'We believe,' he says, 'that the primary purpose of the stinging is to overcome resistance, and to prevent the escape of the victims, and that incidentally some of them are killed and others are paralyzed.'"

And so for all the other cases of so-called invariable and unerring instincts. We now know that birds vary their nest building according to the situation and the materials available for the purpose; that chickens, although they can peck as soon as they are born, do not peck unerringly at first; that spiders make their later webs better than their earlier ones; that the second nest of a bird is better built than the first; that bees and wasps often lose their way; that thousands of birds during migration fly out to sea, especially in foggy weather, and perish miserably; that birds fly imperfectly at first and improve with practice; that cuckoos deposit their eggs in any nest that is available and do not seek out the nest of a particular species—say the hedge-sparrow; and that dogs get lost far oftener than human beings.

Moreover instincts and capacities may be changed or transferred. A fighter of boys may develop into a fighter of wrongs. A collector of stamps or cigarette-cards may become a collector of facts later in life. The bully of the playground may be used with effect to protect the younger boys. The maternal instincts of adolescent girls may be wasted on cats, dogs or parrots when womanhood is attained. Every teacher should strive to direct all useful instincts along desirable channels: undesirable instincts should either be inhibited or modified so as to become of real service to the possessor.

Instincts need a stimulus, they are not impulsive. Instincts do not come out willy-nilly; even the strongest of them needs some stimulus, however slight, to set it off. Capacities need a complex stimulus or rather a series of complex stimuli in order to develop them. But the fact that instincts resemble a wound clock-spring in that they go on by themselves when they are set going, has caused some psychologists (including James) to say that they are impulsive. They are only impulsive in the sense that most of them are very easily aroused and that the exercise of them is itself the stimulus which causes their continuance, and may indeed be the starting-point of a whole series of instinctive and learned reactions. For example, the sight of a puddle is sufficient to make a boy of four paddle in it, play with it with his hands, splash other boys, try to drain it, sail stick boats upon it and do a host of other things besides. Thorndike[1] calls this a "multiple reaction to a single stimulus. It is, at bottom, the basis of the educability of human beings."

[1] *Elements of Psychology*; p. 191.

Control of Instincts and Capacities. Desirable instincts may be preserved by providing stimuli for their development into permanent habits. Undesirable ones may be destroyed by disuse, *i.e.* by withholding stimuli until such times as the instincts have faded away. But the method is a dangerous one to rely upon, for, as we have seen, instincts are easily aroused and the stimuli for their development are well-nigh omnipresent. A much safer way of destroying them is to give punishment whenever they are exercised. Thus the natural instinct of grabbing is destroyed, so far as table manners of children are concerned, by punishment and disapproval (a type of punishment) on the part of their parents. The undesirable instinctive action is inhibited by making the consequences sufficiently painful or uncomfortable. So far as school is concerned, by far the best plan is that of substitution, *i.e.* utilising the driving force of the instinct but directing it into safer outlets. Few instincts are so definite that they are incapable of re-direction. Vague curiosity about persons and dress may be changed into definite and absorbing curiosity about natural history or English literature. Collecting and hoarding useless things may be directed into the accumulation of things and facts really worth while. Even the language capacity which is normally satisfied with the vernacular may be directed with great success towards French, German, Latin or Greek providing the re-direction is begun early enough. In the same way the general desire for manipulation in the young may lead to the finished craftsman of later life.

Theories of Instincts. It has been customary to explain instincts on one of two theories: first, that they are relics of far-away ancestors (see Chap. I.), and second, that they are chance or fortuitous variations (with or without the power of use or disuse) which have been selected because of their usefulness to the organism. Quite recently Loeb[1] and other mechanists (those believing in an exclusively physical and chemical interpretation of life), while not denying that instincts are hereditary, have tried to explain how certain simple instincts operate. Loeb states "if a moth be struck by the light on one side, those muscles which turn the head towards the light become more active than those of the opposite side, and correspondingly the head of the animal is turned towards the source of light. As soon as the head of the animal has this orientation and the median-plane (or plane of symmetry) comes into the direction of the rays of light, the symmetrical points of the surface of the body are struck by the rays of light at the same angle. The intensity of light is the same on both sides, and there is no more reason why the animal should turn to the right or left, away from the direction of the rays of light. Thus it is led to the source of the light. Hence the 'instinct' that drives animals into the light is nothing more than the chemical—and indirectly the mechanical—effect of light, an effect similar to that which forces the stem of the plant at the window to bend toward the source of light." In the same way Loeb proved that "the tendency of many animals to creep into cracks and crevices has nothing to do with self-concealment, but only with the necessity of bringing the body on every side in contact with solid bodies." Crucial experiments in which the instinct was reversed were performed with a number of marine animals which normally go away from light. They were forced "to go to the light in two ways, first by lowering the temperature, and second, by increasing the concentration of the sea-water (whereby the cells of the animals lose water)." The subject is a fascinating one and further experiments should be eagerly welcomed.

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[1] *Comparative Physiology of the Brain and Comparative Psychology*; Chap. XIII.

Order of Development of Instincts. Instincts in human beings develop in a fairly definite order. The instincts of clasping and sucking are the first to develop, while those connected with sex are the latest. They obey the bio-genetic 'law' or the 'law' of recapitulation—a law best known under the title of the "culture epoch theory." According to this theory, either the order of development of instincts in the individual child is the order of their development in the race, or a child has all the instincts that the race has had and they develop in the order of acquirement. This theory in its extreme form has been abandoned, yet it serves as one of the most suggestive generalisations of psychology. There is much that is missing and there is a great deal of overlapping and distortion. For instance, sex instincts develop late in the individual, yet they must have been present in the race from its earliest beginnings. Curiosity is late with monkeys yet comparatively early in children.

Paddling in water must have preceded the climbing of trees by aeons of years, yet a boy paddles in water and climbs trees at about the same age. We certainly do not get one month as a primate, one year as a savage, and so on, in the development of children.

Classification of Instincts. Mark[1] has made the following classification of instincts. He divides them into three groups: (1) those which have marked motor qualities—climbing, walking, hunting, fighting, playing and so forth; (2) those which have an intellectual reference—curiosity, spontaneous attention (or interests), and general mental activity; and (3) those which have a marked accompaniment of feeling—fear, pugnacity, self-reliance, instincts connected with sex.

The classification used by Holmes in *What is and What might be* (p. 165), is interesting because it shows the broad conception of instinct which laymen usually hold. According to Holmes there are six things which the child instinctively desires:

1. To talk and listen (communicative)	sympathetic instincts.
2. To act—in dramatic sense (dramatic)	
3. To draw, paint and model (artistic)	aesthetic instincts.
4. To dance, to sing (musical)	
5. To know the why of things (inquisitive)	scientific instincts.
6. To construct things (constructive)	

Instincts and Emotions. McDougall in his *Social Psychology*[2] has pointed out the close connection which exists between instincts and emotions. Thus the instinct of flight and the emotion of fear are inseparably connected in man. In the same way there are connections between the instinct of repulsion and the emotion of disgust; between the instinct of curiosity and the emotion of wonder; between the instinct of pugnacity and the emotion of anger; between the instincts of self-abasement (or subjection) and of self-assertion (or self-display), and the emotions of subjection and elation (or negative and positive self-feeling); and between the parental instinct and the tender emotion. There is little doubt that the performance of such an instinctive act as flight is invariably accompanied by the emotion of fear and it is on these grounds that the James Lange theory of emotions is based. (See Chapter XVI. for a further discussion of this topic.)

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[1] *The Unfolding of Personality*; Chaps. III., IV. and V.

[2] Chaps. II., III. and IV.

Instincts of Special Importance to the Teacher. 1. *Play.* Play is an activity pursued for the pleasure or satisfaction which the activity itself provides, without any reference to its ultimate usefulness. The physiological work done during play is not felt as effort. Play is the antithesis of drudgery and between play and drudgery comes work. But the boundaries between play, work and drudgery are vague and ill-defined. The characteristic feature of work is that in its performance some aversion, either overt or covert, must be overcome; the activity is pursued for some remote end and never for its own sake. From another point of view, the difference between work and play is that of spontaneous as opposed to purposeful (or effortful) action. Work demands a greater amount of intelligence than play. It applies means to accomplish a remote aim.

Since children are instinctively active and find it hard to suppress movement, play becomes for them an important instrument of education. When the vitality characteristic of childhood wanes, the educational importance of play disappears also. It is futile to make play the basis of the education of the adolescent and the university man because those factors which make play valuable for children have either disappeared or changed their character. Play with young children is dominantly individualistic, with boys and youths it is mainly social in character. In social play (games) rivalry and imagination are fostered, but the most valuable lesson taught by games is the necessity for co-operation and the due subordination of self to the good of the whole. Some objections to play as the basis of educational practice[1] are: (1) that it fails to get work done unless the child acquiesces, and (2) it fails to inculcate the spirit of work. Work is always done with an ulterior motive and therefore some form of coercion is essential. The essence of play is free choice; one cannot compel children to play. Play as an educational principle inevitably breaks down with older children; it may serve as a preparation for avocations but not, unless by accident, for vocations. It is on these grounds that the plea for "discipline" in school is based; and discipline is a factor in education which is in danger of neglect at the present time.

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[1] See Nunn: *The Play Motive in the Higher Classes of the School*; Educational Times, November 1st, 1912. Nunn is inclined to believe that play may be used as a motive throughout the whole of school life.

The various theories of play which have been advanced, have emphasised one or more of these characteristics of play, but none of them can be wholly accepted. The theory of relaxation [1] emphasises the importance of change of occupation as a rest for mind and body, but it fails to account for the fact that play often recreates better than rest, and that play is most vigorous when the subject is least in need of recreation.

The theory of superfluous energy put forward by Schiller [2] and Spencer [3] is useful but it fails to show why children sometimes play "until they drop." If it is interpreted to mean that in play it is the energy most easily set free which is utilised we are able to accept it, but this is hardly the construction the originators of the theory put upon it.

The atavistic theory of play of Stanley Hall,[4] namely, that play is a relic, or is reminiscent of the useful actions of far off ancestors, is also open to question. "I regard play as the motor habits and spirit of the past of the race, persisting in the present, as rudimentary functions sometimes of and always akin to rudimentary organs. . . The young grow up into the same forms of motor activity, as did generations that have long preceded them, only to a limited extent, and if the form of every human occupation were to change to-day, play would be unaffected save in some of its superficial imitative forms." The theory certainly explains why many of the plays of the young Fiji islanders are like those of the slum children of London, but to imply that the differences between them are negligible is to under-rate seriously the element of imitation in play.

The theory of play as a preparatory exercise emphasises its educative nature, and is now very widely accepted. It originated with Groos and has been elaborated in three works, two of which have been translated into English.[1] Groos pointed out that the play of young animals resembled some of the adult activities of the same species. Puppies do not butt one another as do kids or lambs because worrying is the adult activity of dogs. Puppies, therefore, chase and worry one another. Similarly a moving ball of worsted or paper is irresistibly fascinating to a kitten but leaves a calf unmoved. Groos further considers such play activities are necessary to the proper development of the animal. "A little rabbit must have played the rabbit for a certain time in order to become a perfect rabbit; a chick must have played the cock or the hen for some months in order to become a good one; the kid must have cut many capers before becoming a goat or a chamois worthy of the name. Also, our children must have played long years at being men and women in order to truly become men and women. It may therefore be said with Groos that it is not because the animal is young that he plays, but that he has youth because he needs to play."[2]

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[1] Lazarus: *Die Reize des Spiels.*

[2] Schiller: *Letters on the Aesthetic Education of Mankind.*

[3] Spencer: *Principles of Psychology*; Vol. II., Ch. IX.

[4] Hall: *Adolescence*; I., p. 202 ff.

McDougall is inclined to think that it is in the "impulse" of rivalry that we shall find the true explanation of play. "The impulse of rivalry is to get the better of an opponent in some sort of struggle; but it differs from the combative impulse in that it does not prompt to, and does not find satisfaction in, the destruction of the opponent. Rather, the continued existence of the rival as such, but as the conquered rival, seems necessary for its full satisfaction, and a benevolent condescension towards the conquered rival is not incompatible with the activity of the impulse, as it is with that of the combative impulse. Now, these peculiarities of the impulse of rivalry, when stripped of all intellectual complications, seem to be just those of the modified form of the combative impulse that seems to underlie the playful fighting of young animals. May it not be, then, that the impulse of rivalry is essentially this impulse to playful fighting, the impulse of an instinct differentiated from the combative instinct in the first instance in the animal world to secure practice in the movements of combat?"[3]

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[1] Groos: *The Play of Animals*; 1896; *The Play of Man*; 1899; *Der Lebenswert des Spieles*; 1910.

[2] Claparède: *Experimental Pedagogy*; p. 125.

[3] McDougall: *Social Psychology*; p. 113.

The fact of the matter is that play is sufficiently complex to fit in with all the theories. Play is undoubtedly reminiscent of useful activities of our ancestors; it is undoubtedly a preparation for the serious activities of later life ; it has undoubtedly, as its main element, the "impulse" of rivalry ; it undoubtedly first uses up the superfluous energy of the individual ; and it undoubtedly serves in many cases as a means of recreation. But exceptions to all the explanations advanced by these theories can be found.

One word more about the imitative factor in play. In our day, a chair duly harnessed served admirably as a coach and six ; to present-day children, a chair serves as an excellent motor car ; to our grandchildren, a chair will render yeoman service when the play for the day is "aeroplanes."

2. *Curiosity.* This instinct is closely associated with attention and interest. Curiosity produces attention, and attention arouses interest. The mind instinctively likes to be active and curiosity is a means whereby new ideas are introduced to the mind. But it is just as difficult to be curious about the absolutely new thing as about the absolutely well-known. Novelty arouses the instinct but the new thing must not be too novel to be comprehended. And with young children the strikingly unfamiliar or unknown is apt to arouse fear instead of curiosity.

The curiosity of children—the puzzling questions they ask—is almost too well known. The function of the teacher is to guide this curiosity into profitable channels or else in later life it will be wasted upon tittle-tattle, scandal, dress, or other equally useless things. It is almost as easy to make children curious about the great things of nature, literature and art as about the cup-tie football results or the "snippity-bits" of the "yellow press." Generally speaking, it is because the worthy interests of life have been denied children that their innate curiosity has satisfied itself with unworthy and ignoble things.

3. *General Physical Activity.* By this is meant the general manipulation of objects. Its extreme forms are constructiveness and destructiveness. It is closely allied with curiosity, and it is to this combination that we must ascribe such acts as opening the drum "to see where the noise comes from." It is the basis of the love that children have for tools, and it is the mainspring of manual

work in all its forms. As an educative instrument it is relatively more important in the young than in grown-ups, but there is no doubt that most adults would have more chances of happiness if the instinct were still alive in them. Modern civilisation, with its machinery, tends to kill off the instinct early, with the inevitable result—a degradation or destruction of handicraft. The cultivation of this instinct in the school would lead to a resuscitation of handicrafts in the home.

4. *Acquisitiveness.* This instinct, which is generally called the collecting instinct, is closely associated with miserliness or ownership. It is practically universal and develops about the age of three years. Between 10 and 14 it is at a maximum. The nature of the collection is determined by environment and by imitation. In childhood there is a crude instinct to collect anything; in pre-adolescent years the collection is more purposeful[1] and there is the additional element of trade. In fact the economics of cigarette-card collecting is most instructive and amusing. The instinct may be best utilised in the teaching of geography, nature-study, history and art, but there are few school-subjects in which it cannot be used. Children take better care of their own property than they do that of others, hence schools should not furnish books unless they are given to the children outright.[2]

5. *Fear.* This instinct has largely diminished in importance by the time school-age is reached. Fear is universal in children and is generally out of all proportion to the existing cause.[3] As complete knowledge eliminates fear, the obvious way to meet fear is by education. Fear is the mother of superstition, and excessive fear makes for selfishness and weakness. The bully is often a coward at heart. The use of fear as a corrective in school is, however, often prolonged beyond its period of usefulness; it may have a belittling and degrading effect which persists throughout life.

[1] Caroline F. Burk: *The Collecting Instinct*; Ped. Sem., VII., 179-207.

[2] See Kline and France: *Psychology of Ownership*; Ped. Sem., Vol. VI.

[3] G. Stanley Hall: *A Study of Fears*; Amer. Journ. Psy., VIII., pp. 147-249.

6. *Language.* The importance of this capacity demands a separate chapter. (See Chapter XIX.)

References. Baldwin: *Mental Development in the Child and the Race.* Claparède: *Experimental Pedagogy.* Cummings: *New Methods in Natural History*; World's Work, Dec. 1912. Groos: *The Play of Animals.* Groos: *The Play of Man.* Hall: *Notes on Study of Infants.* Hall: *Adolescence*, I. Henderson: *Text-Book of Principles of Education.* James: *Principles of Psychology*; Chap. XXIV. Kirkpatrick: *Fundamentals of Child Study*; Chaps. III.-XIII. Lloyd Morgan: *Animal Behaviour.* Mark: *Unfolding of Personality*; Chaps. III., IV. and V. McDougall: *Social Psychology.* Preyer: *The Mind of the Child.* Romanes: *Mental Evolution in Animals and Man.* Shinn: *Biography of a Baby.* Sully: *Studies of Childhood.* Thorndike: *Animal Intelligence.* Thorndike: *Elements of Psychology*; Chap. XII. Thorndike: *Notes on Child Study*; Chap. V. Thorndike: *Principles of Teaching*; Chap. III. Washburn: *The Animal Mind.* Welton: *Educational Psychology*; Chap. IV.

CHAPTER IX.

HABIT AND RELATED TOPICS.

The Essential Unity of Mind. In order to prevent misunderstandings in this and later chapters it will perhaps be useful at this point to emphasise the fact of the essential unity of the mind. Just as the whole of the body is involved when we play football or billiards, so the whole of the mind is involved when we are said to perceive, to think, or to listen to a lecture. In football the legs are more dominantly active than the arms, while in billiards the situation is reversed. Such considerations as these do not prevent us from analysing our complex bodily activities into simpler elements and, if we so desire, from arranging sets of drill exercises for the development of special parts. Some bodily exercises, like swimming or rock-climbing, seem to be so diffuse as to affect all parts of the body equally, but even these may be analysed into simple components. Exercise of one part is dependent upon the whole, and, in turn, affects the whole. So in psychology : when we speak of perception, association, memory, habit and the like we are simply segregating and emphasising some special form of mind activity. In some kinds of mental work memory may play a greater part than in others, but it is present in all types to a certain extent. Some aspects of mental life correspond to the swimming and rock-climbing types of physical exercise, where the difficulty of analysis is great because of their complexity, and where the fatigue point is easily reached. If the reader will bear this warning in mind when he is reading of memory, association, perceptions, etc., he will avoid the mistake of thinking that these activities can go on by themselves quite apart from all other aspects of mental life.

HABIT.

Connection between Habit, Practice and Fatigue. Some aspects of mental life are more nearly related than others. Habit, practice and fatigue would seem to be three which have close affinities. Practice is necessary if habits are to be formed, while fatigue may interfere with practice. The close relationship existing between them will be emphasised in this chapter.

Since James wrote his epoch-making article on "Habit" in the *Popular Science Monthly*[1] for February, 1887, comparatively little has been added to our knowledge of the psychology of habit formation. This section, therefore, is frankly based on that of James, with the addition of such information as has subsequently been brought to light.

Definition of Habit. "Habit is an acquired aptitude for some particular mode of automatic action."[2] "Tendencies to respond which are created in whole or in part by experience, practice or training are called habits."[3]

These definitions emphasise the two important features of habits, namely, that they are automatic, and that they are acquired during the lifetime of the individual. The automatic nature of habits ensures their performance with a minimum amount of attention, consciousness and fatigue. Consider a child learning to write, or an adult learning to skate or to ride a bicycle. The attention which at first must be devoted to the task in hand is almost overwhelmingly great, as is shown by the susceptibility to fatigue, but with repeated practice the actions are performed almost without consciousness and the person is able to sing and write, to think out abstract problems and ride a bicycle, and to skate and talk without quite knowing how they were done after the actions are completed and all with a minimum of effort and fatigue. The second factor—the acquirement during the lifetime of the individual by experience, practice and training—differentiates habitual from instinctive actions, which are, of course, prior to experience.

The definitions also enable us to avoid the common error of thinking that only perfected automatic actions such as the "bad habits" of smoking, drinking and swearing are to be described as habits. We may have habits of thought as well as habits of action. Probably 99 per cent. of all we think and do is habitual.

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[1] Reprinted in *Psychology*, I., Ch. 4.

[2] Maher: *Psychology*, p. 388. Quoted by Rowe.

[3] Thorndike: *Elements of Psychology*; p. 16.

Some habits seem to be entirely automatic, while others seem to possess an element which never can become automatic. Hence only part of the action may truly be described as habitual. The actions which are involved in playing cricket, boxing and fencing are of this type. The actual strokes at cricket, the blows and guarding of blows in boxing and the lunging and parrying at fencing are automatic, but constant alertness, the opposite of automatic, must be the order of the day if success is to be attained in any of these activities. With walking it is otherwise: one may read and walk at the same time without seriously hampering the efficiency of either performance. Walking, therefore, is more purely a habit than is fencing.

The Physical Basis of Habit. All writers are agreed that habit has a physical basis in the structure and action of the central nervous system. James states that it is due to the plasticity of the nervous system. "Plasticity, then, in the wide sense of the word, means the possession of a structure weak enough to yield to an influence, but strong enough not to yield all at once. Each relatively stable phase of equilibrium in such a structure is marked by what we may call a new set of habits. Organic matter, especially nervous tissue, seems to be endowed with a very extraordinary degree of plasticity of this sort; so that we may without hesitation lay down as our first proposition the following, that the phenomena of habit in living beings are due to the plasticity of the organic materials of which their bodies are composed." . . .

"The most complex habits are nothing but concatenated discharges in the nerve centres, due to the presence there of systems of reflex paths, so organised as to wake each other up successively—the impression produced by one muscular contraction serving as a stimulus to provoke the next, until a final impression inhibits and closes the chain. The only difficult mechanical problem is to explain the formation *de novo* of a simple reflex path in a pre-existing nervous system."[1]

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[1] James: *Psychology*, I., pp. 105 and 108.

In place of James's paths, we must now substitute neurone systems. We have seen previously that at each synapsis there is a resistance to the passage of the nervous impulse. Habit formation is nothing more nor less than the breaking down of these resistances at the synapses by successive nervous discharges. The stronger and the more frequent the discharge, the sooner is the resistance broken down, *i.e.* the sooner the habit is established. Verworn has also shown [1] that nerve cells increase in size by use, and that the strength of the nerve impulse depends upon the size of the cell body. Nerve cells which have not been used act as a block to the passage of a current.

The frontal lobes seem to have a close connection with habit formation. Franz,[2] after having taught a cat or monkey certain specialised acts, such as getting into a cage by turning a certain button or pulling a certain string, removed the frontal lobes and again tested the animal. In all cases the act was forgotten. Removal of other parts of the brain occasioned no such loss, hence he concluded that the frontal lobes are concerned in the acquisition of new performances of the kind used.

But the difficulty of explaining why the first discharge takes place still remains. We can speak glibly of inherited organisation of neurones but this only explains part of the difficulty. In what way does a man learn to control the evolutions of an aeroplane? Hereditary dispositions count for very little here. There are, of course, the eleven thousand millions of neurones but why one path should be taken or chosen by the current rather than another is still wrapt in mystery. It is certainly not an illustration of the law of chance.

Growth of Instinct into Habit. My wife's dog often astonishes visitors by his ability to pick out the ace from a pack of cards. The cards are placed in a semi-circle around him and when the order "pick out the ace" is given he puts a paw upon the ace. He does the trick equally well if the cards are turned face down. Various explanations of the manner of doing it are given by the audience, the most frequent one being that "he smells it." But the explanation is really much simpler. Every dog has the instinct to paw things placed in front of him. This instinct has been encouraged and developed by suitable gifts of food attendant upon success. The cards are placed so that the ace reposes nearest to the right paw in whatever position he happens to be sitting. As soon as the signal is given, out goes the right paw on the card nearest to him, which, in this case, is invariably the ace. The instinct of pawing has been hardened into a definite habit of pawing in which all unsuccessful actions have been eliminated.

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[1] British Association Meeting, Dundee, 1912.

[2] *The Frontal Lobes*: Archives of Psychology, 1907, No. 2. Quoted by Ladd and Woodworth.

" A monkey was kept in a large cage. Into the cage was put a box, the door of which was held closed by a wire fastened to a nail which was inserted in a hole in the top of the box. If the nail was pulled up out of the hole, the door could be pulled open. In this box was a piece of banana. The monkey, attracted by the new object, came down from the top of the cage and fussed over the box. He pulled at the wire, at the door, and the bars in the front of the box. He pushed the box about and tipped it up and down. He played with the nail and finally pulled it out. When he happened to pull the door again, of course it opened. He reached in and got the food inside. It had taken him 36 minutes to get in. Another piece of food being put in and the door closed, the occurrences of the first trial were repeated, but there was less of the profitless pulling and tipping. He got in this time in 2 minutes and 20 seconds. With repeated trials the animal finally came to drop entirely the profitless acts and to take the nail out and open the door as soon as the box was put into the cage. He had, we should say, learned to get in." [1]

" To illustrate this quick learning (*i.e.* where an animal learned to do a trick almost immediately) we will make brief mention of a hitherto unpublished experiment [2] on a chimpanzee—a species, which, to judge by cerebral development, stands considerably higher than the smaller monkeys. The specimen tested was a young female, about half-grown, and corresponding in relative maturity, perhaps, to a child of the human species of ten or twelve years. A box was prepared, having a slatted front with a door closed by a button, a turn of which through 90° released the door. The chimpanzee, on being placed in front of this box, in which a piece of banana had been placed before her eyes, quickly came to devote most of her efforts to the door (which allowed of some slight motion even with the button closed)—pushing it outward, pushing it inward, and shaking it. She soon also attacked the button, and alternated, for the most part, between this and the door. In this way, it was not long before she turned the button through 90°, then tried the door, and got in, thus securing the food. On a second trial, the chimpanzee worked almost entirely at the door and the button, and from the third trial on, her reaction was uniformly prompt and correct. After several more trials, a second button was added a few inches from the first, but much like the first in appearance and operated in the same manner. The chimpanzee attacked the box as before, neglecting the second button. After once turning the first button, and pulling the door, which, of course, did not yield, she turned the first button again, so locking the door; then again tried the door and continued in this way for a long time, before passing to the second button and dealing similarly with it. Entrance was finally secured by a chance placing both buttons at once in the right position. In the course of several trials, no further progress was made. It seemed to be wholly a matter of chance whether both buttons should be put right at once or not."[1]

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[1] Thorndike : *Animal Intelligence* ; p. 283.

[2] This experiment was performed by R. S. Woodworth in 1902-3, in the laboratory of Professor Sherrington at Liverpool.

"A dog (a fox terrier, 14 months old) was sent after a short stick into a field, and had to pass through vertical rails about six inches apart. On his return the stick caught at the ends. I whistled and turned as if to leave; and the dog pushed and struggled vigorously. He then retired into the field, lay down, and began gnawing the stick, but, when called, came slowly up to the railings and stuck again. After some efforts he put his head on one side and brought the stick, a short one, through. After patting and encouraging him, I sent him after it again. On his return he came up to the railings with more confidence, but, holding the stick by the middle, found his passage barred. After some struggles he dropped it and came through without it. Sent after it again, he put his head through the railings, seized the stick by the middle and then pulled with all his might, dancing up and down in his endeavours to effect a passage. Turning his head in his efforts, he at last brought the stick through. A third time he was again foiled; again dropped the stick; and again seizing it by the middle tried to pull it through. I then placed the stick so that he could easily seize it by one end and draw it through the opening between the rails. But when I sent him after it, he went through into the field, picked up the stick by the middle, and tried to push his way between the railings, succeeding, after many abortive attempts, by holding his head on one side.

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[1] Ladd and Woodworth: *Elements of Physiological Psychology*; p. 552.

Subsequent trials on many occasions yielded similar results."[1]

These three quotations show in the main how complex habits are fixed in animals. The basis seems to be instinctive random movements. Some variant, in the successful cases, is selected out by reason of the pleasure enjoyed as a result of its performance, and then is hardened by repetition into a habit. In some cases, however, failure results because the task is beyond the intelligence of the animal. Similar results have been obtained with chickens, turtles, frogs, rats, mice, cats, birds and raccoons.[2]

In exactly the same way the instinct of language which begins as a babble is hardened into the habit of talking through the reward of successful efforts. The instinctive act of walking is rewarded by so many pleasant experiences that it is invariably hardened into the habit of walking. Grabbing, on the other hand, which is equally instinctive, is so often reproved and punished that in most people it fails to develop into a habit.

Habit again may develop out of habits. There is very little doubt that creeping leads on to standing and walking. In this case additional instinctive actions would seem to be necessary at each stage. In language development the higher products are dependent upon the lower and simpler habits which are derived from instincts.

Laws and Maxims of Habit Formation. Thorndike[3] gives the following laws and maxims of habit formation. "Any mental state or act which in a given situation does not produce discomfort becomes associated with that situation so that when the situation recurs the mental state or act is more likely than before to recur also ; the greater the satisfaction produced by it, the stronger the association. Conversely, any mental state or act which in a given situation does produce discomfort becomes disconnected from that situation, so that when the situation recurs the mental state or act is less likely than before to recur also ; the greater the discomfort produced by it, the weaker the association becomes. *Or* in any situation the mental state or act will take place which has resulted from that situation oftenest and with the most satisfaction."

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[1] Lloyd Morgan: *Animal Behaviour*; p. 141.

[2] For Bibliography see Ladd and Woodworth: *Physiological Psychology*; p. 547.

[3] *Elements of Psychology*; p. 205: *Principles of Teaching*; p. 110 ff.

From these laws, the following maxims arise : "Put together what you wish to have go together. Reward good impulses. Conversely ; keep apart what you wish to have separate. Let undesirable impulses bring discomfort."

If these rules were followed such stupid mistakes in teaching as the following would never be made : (1) Giving school tasks for punishments, thus associating in the child's mind the ideas of school-work and punishment. (2) Teaching multiplication tables by a monotonous drone from $2 \times 1 = 2$ to $12 \times 12 = 144$. The situations in which a product of two factors is needed in ordinary life, are never those of the sequences of tables. If $7 \times 7 = 49$ is always learned as something which follows $7 \times 6 = 42$, $7 \times 5 = 35$ and so on, then it cannot be recalled without reference to preceding parts of the table. The same thing happens with the alphabet. The writer, to this day, has to repeat a few of the preceding letters before the position of the one wanted is recalled. (3) Writing up spelling mistakes on the Black Board, or reciting them aloud in order to get the correct form. A similar situation is seen when classes are given words purposely mis-spelled and told to give the correct forms. The wrong form is taught instead of the right one. (4) Correcting spoken language errors by giving both the right and wrong pronunciations. Only the correct forms should be emphasised. In fact so powerful is the mere association of things that the best way of destroying a dialect is to reside for some time in a place where a different and better one is spoken. The errors are swamped by perfectly unconscious imitation. (5) Trying to teach foreign languages by learning declensions, conjugations and rules. These particular forms of word sequences are never met with in the living (or dead) language. Yet how many of us when *Nous avons* is mentioned immediately conjure up *vous avez*, simply because *nous avons* was always followed by *vous avez* in our learning of the language! The success which has attended the direct method of teaching French, German and Latin is due to the fact that the teachers have put together those things which they wanted to go together. (6) Teaching to read by the alphabet method. Why should scholars be expected to associate curly strokes c-a-t—pronounced see-eh-tee—with the sound cat! In reading, the word cat has not to conjure up its constituent letters, but the idea of a purring domestic animal called by a name which sounds cat. In just the same way the reading books for beginners often associate together that which is never associated in real situations. Children will learn to read from the " Water Babies " just about as quickly as from sentences like " Nan sat on a tin can."

The rules given by James, who follows Bain, are self-explanatory and do not need discussion. They are as follows: " (1) In the acquisition of a new habit, or the leaving off of an old one, we must take care to launch ourselves with as strong an initiative as possible. (2) Never suffer an exception to occur till the new habit is securely rooted in our life. (3) Seize the very first possible opportunity to act on every resolution we make, and on every emotional prompting we may experience in the direction of the habits we aspire to gain. (4) Keep the faculty of effort alive in us by a little gratuitous exercise every day. (5) Make our nervous system our ally instead of our enemy. For this we must make automatic and habitual, as early as possible, as many useful actions as we can." These maxims have special force in the realm of morals.

Other factors in habit formation which ought to receive attention are: (1) Repetition. Practice is necessary, for no habit can be learned by one trial. It ought to be recognised that " practice makes perfect," only when the resultant act produces satisfaction. (2) Attention. The number of repetitions needed for the perfecting of the habit is less when attention is concentrated. (3) Fatigue. Habits are difficult to form when the subject is fatigued, because no pleasant results can accrue. (4) Preliminary notions. The child should be helped to get some idea of the habit we wish to form.

The Breaking of Habits. In reality there is no such thing as breaking a habit, if by that phrase is meant a stamping out of part of one's life. What really happens is that the nervous discharge is diverted from its ordinary channel into some other. The old habit is "broken" as soon as the new path of discharge is stronger than the old one. The old action is then more difficult to perform than the new one. If, however, there is a relapse, the old track is very easily opened, for traces of it remain and become functional. A conversion, to be lasting, must be followed by many hard struggles towards righteousness; resolves made under the stress of emotion are apt to fade into thin air when the emotion has evaporated.

Habit and Formal Discipline. The formation of habits has been the chief battlefield of the protagonists in the fight over the question of formal (or mental or general) discipline. The question at issue is "does practice and improvement in one thing—say habit formation or memory—lead to improvement in another, without specific exercise of the latter?" Does study in Latin improve English or Geography and, if so, to what extent? Does improvement of neatness in dress carry over to neatness of school-exercises and to the orderly arrangement of one's work? It is generally admitted that there may be such transfer of training, but it is very much smaller than is usually supposed. There must, however, be identical elements in the two branches. These identities may be of method, of material, and of aim. The fight has been waged fiercely during the past fifteen years and so many researches have been published that a volume instead of a paragraph would be needed to do justice to them. A short bibliography of the more valuable works dealing with habit formation is given below.[1]

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[1] Coover and Angell: *General Practice Effect of special exercise*; Amer. Jour. Psy., July, 1907.

Davis: *Researches upon Cross Education*; Yale Psychological Studies, 1898.

Scripture, Smith and Brown: *On the Education of muscular control and power*; Yale Psychol. Studies, 1894.

Ebert and Meumann: *Ueber einige Grundfragen der Psychologie der Uebungsphänomene im Bereiche des Gedächtnisses*; Archiv für die gesammte Psychologie, IV., (1905), pp. 1-232.

Gilbert and Fracker: *Effect of practice in reaction and discrimina-*

PRACTICE.

By practice is meant the means we adopt when we wish to acquire some sort of skill. Or in terms of physiology it means the formation of connections within the body by reason of which movements result on the application of appropriate stimuli. These connections are not formed immediately, but are of gradual growth. In the first performance of the movement many conscious procedures are necessary which, in course of time, not only fail to aid the speedy and correct performance of the operation, but actually become hindrances and so are dropped. Practice then is closely associated with the factor of "repetition" in the formation of habit.

The Practice Curve. Many interesting researches have been carried out to discover the manner in which practice actually operates. The first research, now classical, was conducted by Bryan and Harter at the University of Indiana and in Telegraphist Schools of the surrounding States.[1] Bryan was a skilled experimental psychologist and Harter a practical telegraphist. Their subject, telegraphy, was particularly fascinating since it takes many months to acquire even a passable skill in sending and

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tion for sound upon time of reaction and discrimination for other forms of stimuli; University of Iowa Studies in Psychology, I., p. 62.

Johnson: *Experiments in Motor Education*; Yale Psychological Studies, I., X., pp. 81 ff.

Johnson: *Researches in Practice and Habit*; Yale Psychological Studies, I., VI., pp. 51-103.

Judd: *Relation of special Training to general Intelligence*; Educational Review, XXXVI., pp. 28-42.

Myers, Burt & Sleight: *Formal Training*; L.C.C. Conference of Teachers, 1912.

Swift: *Studies in the Psychology and Physiology of Learning*; Amer. Jour. Psy., XIV., pp. 201-251.

Thorndike and Woodworth: *The influence of improvement of one mental function upon the efficiency of other functions*; Psychol. Rev., VIII., pp. 247-261, 384-395, and 553-564.

Winch: *Transfer of Improvement in Memory*; Brit. Jour. Psy., II. (Jan. 1908), pp. 284-293.

Woodworth: *Accuracy of Voluntary Movement*; Psy. Rev. Monograph Supplement, III., 13, 1899, pp. 1-114.

[1] *Studies in the Physiology and Psychology of the Telegraphic Language*; Psychological Review, 1897, IV., 27, and 1899, VI., 345.

receiving, while years of practice are necessary to attain expertness. More than three-fourths of the candidates who begin to learn, fail to reach the 72 words per minute rate which is the slowest employed on main lines. The following diagram will show the general results of practice.

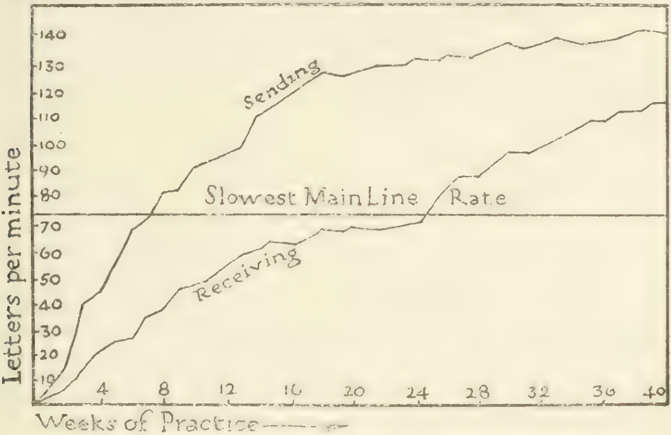

FIG. 24. Curves showing the improvement in sending and receiving telegraphic messages. (Byran and Harter.)

The Morse code of dots and dashes is used and progress is found to be more rapid in sending than in receiving. The dots and dashes of single letters are painfully tapped out at first, but in course of time less attention is paid to these elements; words and even sentences become the units of transmission as greater skill is acquired. In the long run, receiving overtakes sending and the perfection of skill is almost beyond belief. "The feat of the expert receiver—for example, of the receiver of press despatches —is more remarkable than is generally supposed. . . . To bring the sender's rate up to that of the receiver abbreviated codes have been prepared. The receiver must translate the code into English words, and transcribe them, correctly capitalised and punctuated, upon the typewriter. He takes in this way, eighty or eighty-five words a minute. If mistakes are made by the sender, the receiver is expected to correct them as they come, and send a 'clean' copy to press. The work continues for hours without leisure for re-reading, the pages being taken away to press as fast as they are finished" (p. 352).

In both receiving and sending curious periods of no progress were observed; they were, however, much more pronounced in the receiving curve. These flat portions of the curve, which are the preliminaries to new freedom, have been called "plateaus." Bryan and Harter think that these are essential. They consider that the whole process is simply the formation of a hierarchy of habits. Simpler habits are being perfected on the plateau but are not yet automatic enough to leave the attention free to attack more complex habits of a higher order. Intense efforts were found to be the most effective means of rising from a plateau.

Experiments with the typewriter for the purpose of determining the form of practice curve have met with similar results.[1] The general form of the curve is the same as in telegraphy though two or more plateaus appear. As skill increases, especially in the touch system, letters give way to words and words to phrases. The eye, as in reading, is always ahead; the fingers follow steadily behind. Boredom, or lack of interest, seems to be the chief reason for the plateaus in this case.

In order to give some idea of the manner of carrying out such an experiment, a simple one worked out under the direction of the writer, will now be described.

Six students from a class in Educational Psychology at the Manchester University—R. H. B., T. E. K., B. P., E. J., A. R., and E. R. T.—undertook to practise typewriting for an hour a day during each of thirty consecutive days, omitting Sundays, in Session 1911-12. The machine used was an Oliver and no pains were spared to secure and preserve uniform conditions for the experiment. The students practised at the same hour each day and transcribed from the same book. The same amount of instruction (about five minutes) as to the mechanism of the typewriter and its method of working was given to each student by the writer. Five of them had never previously used a typewriter; the sixth, E. R. T., had learned eight years before but in the interval had never touched one. In the computations E. R. T.'s scores are placed in a separate table because his results are really those of re-learning. The method of scoring was first to count the number of words typed in the hour irrespective of correctness or incorrectness, and then, from this table, to deduct an amount for the mistakes made. Each mistake, whether of key wrongly struck, of transposition of letters, of incorrect spacing, or of omission, was counted as one-half, but in no case was more than 1 deducted for a word even though it contained three or more errors. The percentage of errors to words typed was also calculated. The subjects were told to type from a given book as quickly as possible and, at the end of each practice period, to write down any introspections made during the hour.

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[1] Book: *The Psychology of Skill*; University of Montana Publications in Psychology, 1908.

Bair: *The Practice Curve*; Psychol. Rev. Supplement, XIX., 1902, pp. 1-70.

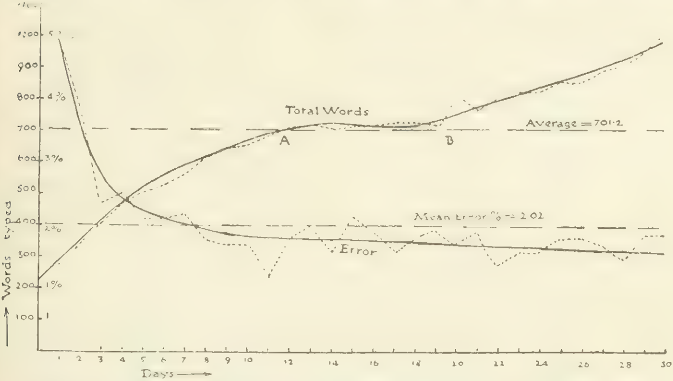

Fig 25. Type-writing practice curve, showing average improvement of five subjects during thirty days.

The results of the five beginners are given in Tables 24 and 25, and Fig. 25; of the re-learner in Fig. 26.[1]

It will be seen from the tables and figures that, although any given subject's performance is somewhat erratic, the general trend is steadily upward, while the percentage of errors decreases with practice; that is, the slower the typing the greater the number of mistakes. This is what we should expect to find; it is the skilled typist who unerringly strikes the right letters ; the novice alone, searching for the keys, makes a large number of errors. It is almost impossible for the beginner to go slowly enough to prevent any mistakes. And the same thing is found in piano-playing and a number of other dexterities.

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[1] I am indebted to a former student, Mr. Joseph Sutcliffe, for the preparation of these tables and diagrams.

TABLE 24.—TOTAL WORDS TYPED CORRECTLY.

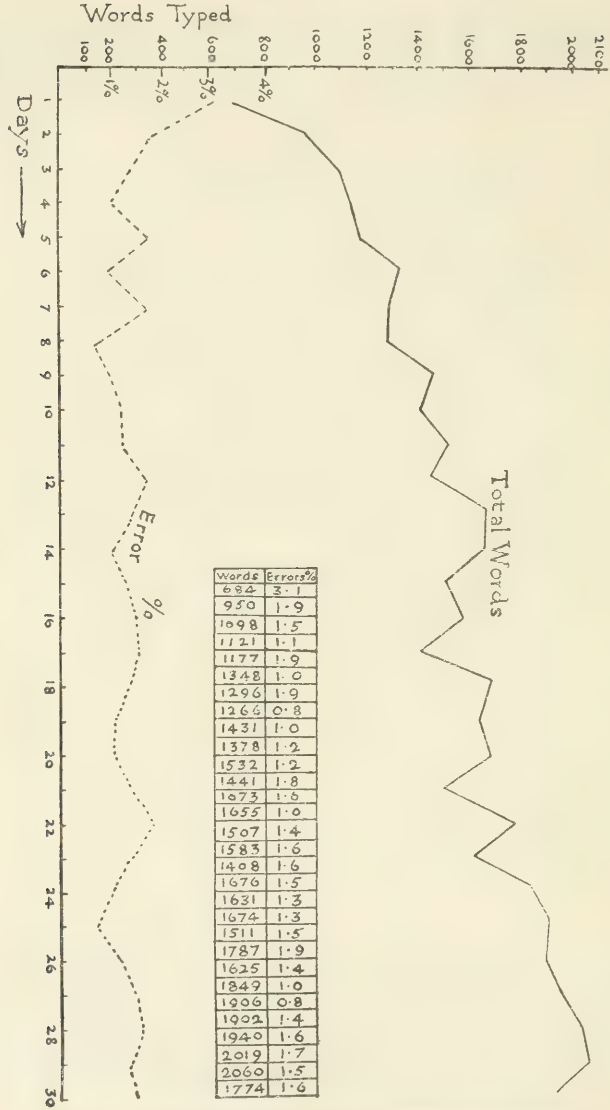
Day.	R. H. B.	T. E. K.	B. P.	E. J.	A. R.	Total.	Average.
1	185·5	405·0	289·5	269·0	224·0	1373·0	274·6
2	231·0	436·0	280·5	504·0	231·5	1683·0	336·6
3	284·0	519·5	261·5	554·0	399·0	2008·0	401·6
4	377·5	543·5	410·0	588·0	438·5	2357·5	471·5
5	392·5	577·5	415·0	636·0	479·5	2500·5	500·1
6	389·0	607·5	401·5	705·0	508·5	2611·5	522·3
7	489·5	731·5	448·0	628·0	614·0	2911·0	582·2
8	502·5	766·5	521·0	664·0	599·0	3053·0	610·6
9	520·5	771·5	544·5	730·0	641·0	3207·5	641·5
10	517·5	827·0	543·5	743·0	624·0	3255·0	651·0
11	563·5	859·5	677·5	770·0	586·5	3457·0	691·4
12	604·0	808·5	700·0	770·0	642·5	3525·0	705·0
13	598·5	824·5	690·5	795·0	625·0	3533·5	706·7
14	639·0	850·0	657·0	831·0	528·0	3505·0	701·0
15	640·5	840·5	725·0	801·0	560·5	3567·5	713·5
16	649·5	865·0	682·0	798·0	621·5	3616·0	723·2
17	696·5	807·5	728·0	799·0	645·0	3671·0	734·2
18	769·0	951·5	710·0	614·0	637·5	3682·0	736·4
19	685·0	954·0	708·0	604·0	705·0	3656·0	731·2
20	797·0	1054·0	802·0	780·0	728·0	4161·0	832·2
21	674·0	973·5	780·0	780·0	703·5	3911·0	782·2
22	746·0	1060·0	721·5	790·0	806·5	4124·0	824·8
23	757·5	1137·0	719·0	755·0	817·0	4185·5	837·1
24	814·0	1103·5	804·5	732·0	725·0	4179·0	835·8
25	727·5	1163·0	848·5	820·0	820·0	4379·0	875·8
26	829·5	1087·5	844·5	750·0	867·5	4379·0	875·8
27	801·5	1203·0	941·0	718·0	849·0	4512·5	902·5
28	806·0	1271·5	928·0	777·0	788·0	4570·5	914·1
29	831·5	1235·5	984·0	821·0	896·5	4768·5	953·7
30	914·5	1356·0	992·0	871·0	..	4133·5	1033·4

Progress is rapid at first and then proceeds more slowly ; the errors obey a similar law, for the percentage rapidly decreases in the early practices. Progress, however, is not uniform. As in the curves for telegraphy, there are periods when no apparent improvement is made and sometimes there is actual retrogression. The re-learner is more variable in his performances than the beginner. If averages are taken and a smooth curve made of the results (see Fig. 25) a plateau is shown running, in this case, from the

TABLE 25.—PERCENTAGE ERROR.

Day.	R. H B.	T. E. K.	B. P.	E. J.	A. R.	Total.	Average.
1	7·8	1·7	4·5	4·5	5·8	24·3	4·9
2	8·0	0·5	3·7	3·2	3·5	18·9	3·8
3	2·9	1·0	3·6	1·9	2·1	11·5	2·3
4	3·7	1·0	3·3	2·6	2·1	12·7	2·5
5	3·1	0·4	2·4	2·3	2·5	10·7	2·1
6	3·7	0·4	2·1	1·5	2·9	10·6	2·1
7	2·5	0·4	4·9	1·9	1·8	11·5	2·3
8	2·2	0·5	2·1	2·3	1·8	8·9	1·8
9	2·9	0·5	1·7	2·1	1·2	8·4	1·7
10	2·2	0·5	2·3	2·2	1·4	8·6	1·7
11	1·4	0·5	1·5	1·8	1·2	6·4	1·3
12	2·3	0·6	2·5	2·7	0·8	8·9	1·8
13	3·8	0·5	2·6	2·4	0·8	10·1	2·0
14	2·9	0·5	2·0	1·5	1·1	8·0	1·6
15	3·7	0·5	3·2	2·3	1·3	11·0	2·2
16	2·6	0·5	2·3	3·1	1·0	9·5	1·9
17	2·7	0·3	1·6	2·7	0·9	8·2	1·6
18	3·3	1·0	1·3	2·5	1·1	9·2	1·8
19	3·7	0·6	2·2	2·2	1·0	9·7	1·9
20	2·7	0·8	1·6	2·5	0·9	8·5	1·7
21	3·3	0·9	2·3	1·6	1·2	9·3	1·9
22	2·6	0·7	1·6	1·5	0·7	7·1	1·4
23	2·4	0·7	2·0	1·9	1·1	8·1	1·6
24	2·2	0·9	2·1	1·8	1·1	8·1	1·6
25	1·9	1·2	2·6	2·1	1·3	9·1	1·8
26	1·8	0·3	2·7	2·6	1·0	8·4	1·8
27	2·0	0·5	3·1	2·1	1·0	8·7	1·7
28	2·4	0·5	2·4	2·2	0·5	8·0	1·6
29	2·6	0·5	2·7	2·7	1·0	9·5	1·9
30	1·6	0·7	2·7	2·4	. .	7·4	1·9

11th to the 19th day. The plateau is followed by a rapid rise, and that the greater freedom is realised, is shown by the introspections. E. R. T. says after the 24th day: "the typing offered no difficulties"; A. R. on the 22nd day—"my speed went up and I think my mistakes are fewer"; B. P., on the 24th day—"commenced with a feeling of certainty and proceeded rapidly."



Words	Errors%
684	3·1
950	1·9
1098	1·5
1121	1·1
1177	1·9
1348	1·0
1296	1·9
1266	0·8
1431	1·0
1378	1·2
1532	1·2
1441	1·8
1673	1·6
1655	1·0
1507	1·4
1583	1·6
1408	1·6
1676	1·5
1631	1·3
1674	1·3
1511	1·5
1787	1·9
1625	1·4
1849	1·0
1906	0·8
1902	1·4
1940	1·6
2019	1·7
2060	1·5
1774	1·6

FIG. 26. Type-writing practice curve of re-learning (one subject).

A second, third or fourth plateau may be observed before the physiological limit of speed is reached. There is, as it were, a series of perchings and flyings, and in the flyings the economic law of "diminishing returns" does not seem to hold very firmly.

These plateaus, as Swift[1] has shown, are found in the learning of foreign languages, in learning to juggle, skate, and swim, and, in fact, in learning anything that takes a considerable amount of time. But perseverance during the time of a plateau invariably brings its own reward. Even in such highly complex things as the development of appreciation and execution in Art, periods corresponding to plateaus are found, but they are separated by years, not by weeks or months. According to Stanley Hall,[2] drawing of the scribble stage is succeeded by one in which the crude drawing is backed by imagination into something it certainly does not represent. This is the golden age for drawing. But at 8 or 9 the child awakens to the realisation that he cannot draw, and from then on, although perceptive powers increase, very little progress is made. If, however, technique is emphasised and properly taught, interest is re-awakened. Meanwhile power to appreciate steadily increases and so, with our present unsatisfactory methods of Art Teaching, we are a nation of consumers or appreciators rather than creators or producers of Art.

Why should plateaus occur? Physiologically, as we have seen, the learning of skills is nothing more nor less than the breaking down of the resistances at the synapses and the connecting up of steadily developing neurones into series of most complicated order. There is, then, apparently no physiological reason why the practice curve should not be as smooth as the "pressure-volume" curve of a gas. The writer is of opinion that interest and its obverse, boredom, are the most important of the factors which determine the shape of the curve. When a plateau is reached the zest of early attempts has begun to fade, and unless other interests are awakened the plateau persists for a long time. It is at such stages as these that the skilful teacher puts forward new incentives. Another factor is fatigue. This, however, seldom complicates seriously the learning of a dexterity in school. "Willing," the setting of the teeth and determining to succeed, must also complicate the problem. But this brings its reward in a newly acquired interest. Lastly, individual differences of endowment and of education play their part. The motor systems of T. E. K. (see earlier) are certainly more efficient than those of other beginners. The problem of method in teaching skills and dexterities is how to reduce the plateau period to a minimum and how to awaken interest by changes of method, or other means.

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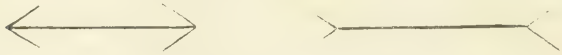
[1] Swift: *Studies in the Psychology and Physiology of Learning*; Amer. Jour. Psy., XIV., pp. 201-251.
Swift: *Mind in the Making*; Chap. VI., 1908.

[2] *Adolescence*, I., 184.

Thorndike[1] has shown that the description of the practice curve for skills as given above holds also in the case of purely intellectual operations. A number of his students were set 96 examples to multiply three-figure numbers by three-figure numbers (excluding 0's, 1's and 2's) "in their heads." The two factors were memorised and pen was not put to paper until the answer was written down. The times taken for each product were noted. The curve was steep at first and the physiological limit of the time taken to do an example was found to be exceedingly low.

It has been shown experimentally that practice dispels the effect of the Müller-Lyer illusion. The reason seems to be that the feature to be judged, in this case the length of the line, is gradually isolated. Practice also increases the speed of reaction-time, although the fairly steady physiological limit is soon reached. Stratton[2] by wearing for a week an apparatus which gave an upright, non-inverted image on the retina, showed that practice easily overcame such a distraction as this. Difficulties of adjustment again arose when the apparatus was removed but were again as easily conquered. These experiments show the exquisite adaptability of the nervous system by means of practice.



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[1] Thorndike: *Effect of Practice in the case of a purely intellectual function*; Amer. Jour. Psy., July, 1908.

[2] *Vision without inversion of the retinal image*; Psy. Rev., 1897, IV., 341, 363.

FATIGUE.

The problem of Fatigue is all-important to educators, yet there is no subject of investigation which has led to such inconsistent and often diametrically opposed results. Part of the difficulty is due to defective terminology. Some writers have used fatigue as synonymous with boredom, lassitude, lack of desire for, or aversion to work, whereas it ought to be rigidly reserved to the fact of incompetency or inability to do work. Again experimenters upon the subject have often measured willingness rather than ability to do work and have neglected the factor of emotional excitement.[1]

Mental and Physical Fatigue. These two forms of fatigue, while distinct in origin, are closely associated, for it is apparently impossible to experience either one or the other in a pure form ; they pass over one into the other and it is difficult to isolate them. Thus a long and tiring tramp causes bodily fatigue, but with the onset of bodily fatigue the intellect becomes duller ; bodily or physical fatigue has passed over into mental or intellectual fatigue. On the other hand, a steady "grind" at some intellectual task is not the best preparation for excessive physical exercise, although it should be noted that it takes a longer time for the effects of prolonged exercise of the nervous system to pass over to the muscles than it does for the effects of vigorous physical exercise to pass over to the nerves.

Causes of Fatigue. There are three main causes of fatigue : (1) *The destruction of the energy-producing compounds* in the body, especially in muscle fibres and in the cell-bodies of neurones. The nutriment of the body, which is absorbed by the blood, is carried by this medium to all parts of the body and is utilised for building up bodily tissue and for providing a store of energy in the form of highly complex, easily decomposable chemical compounds in the katabolic cells of the body. Thus muscle fibres are stored with such energy-producing compounds. When a nervous discharge passes into the muscle these compounds at once break up and it is this rapid decomposition which causes the contraction to take place. In the same way a cell-body of a neurone contains the means of producing the energy of the nervous impulse. If the stimulation of the muscle or neurone is prolonged, a stage is reached when all, or practically all, of the energy-producing compounds have been used up. A state of fatigue is then reached and the parts affected will not function until rest has allowed more of these compounds to be produced and to accumulate. The exact chemical composition of the compounds is as yet unknown. They are, however, exceedingly complex and they decompose with what might almost be termed explosive violence.

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[1] See Thorndike : *Mental Fatigue* ; in Psy. Rev., VII., 1900, 466-482, 547-579 ; and in Jour. of Edcl. Psy., II., 1911, 61-80.

(2) *The presence of toxins or waste products.* When a muscle is exercised waste products or toxins are formed. These toxins are poisonous and their presence in the body in quantity causes the symptoms of fatigue. Elimination of fatigue-substances from the body is primarily effected by means of the circulation of blood and lymph and secondarily by means of the kidneys, skin and lungs. That these toxins alone can produce fatigue was proved by Mosso[1] who injected into the blood of a non-fatigued (fresh) dog, the blood of one which had been excessively fatigued by electrical stimulation, when all the symptoms of fatigue were immediately produced. The chief fatigue substances are sarcolactic acid, $C_3H_3O_3$; mono-potassium phosphate, KH_2PO_4; and carbon-dioxide, CO_2. Injection of solutions of sarcolactic acid and acid-potassium phosphate produce similar fatigue results. On the other hand the flushing of a fatigued frog's body or the washing away of the fatigue products from an extirpated and fatigued muscle causes excitability to return. There are undoubtedly toxins from the action of neurones but these have not been isolated. Nerve substance also recovers so rapidly that it is apparently impossible to fatigue it. On the other hand Sherrington seems to think that the increase of resistance at the synapses, due to an accumulation of waste products of neurone activity, is the primary origin of all the phenomena of fatigue.

(3) *Lack of oxygen.* The decomposition of the energy producing compounds of the body probably cannot take place without the assistance of oxygen from the red corpuscles of the blood. The removal of the fatigue is certainly accomplished in part by oxidation. Hence any

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[1] Mosso: *La fatica*; 1891, p. 119.

impairment of the oxygen supply, or what comes to the same thing, any increase in the amount of substances needing oxidation leads to fatigue. The primary phenomena of muscular exercise, namely a quickening of respiration and an acceleration of the heart-beat, are probably due to the body's increased need of oxygen. But this third cause of fatigue is not so important as the other two and is probably a resultant of them.

Remedy for Fatigue. Nature's remedy is rest and sleep. By this means opportunity for the building up of a fresh supply of energy-producing compounds, and the elimination of waste products by oxidation and otherwise, is provided. But if the fatigue is of a localised mental kind, such as is normally produced by school tasks, the remedy is substitution of another activity. Fatigue causes the inattention so often observable in school-rooms. Inattention is the child's way of making a recovery from fatigue.

The Measurement of Fatigue. Thorndike,[1] criticising the use of physical fatigue as a measure of mental fatigue, states that it supposes the amounts of physical work (1) are functions of the central nervous system; (2) are dependent on such general factors as are at play in mental work and mental fatigue. Therefore (3) we may measure mental inability by physical inability. The first is not proved definitely. The second is mere assumption. The third is an hypothesis to be proved. Ellis and Shipe[2] object to the application of any of the known tests and measures of fatigue to pedagogic and other problems, until more is known about the reliability of such tests. They even go so far as to say that all the present tests and the results obtained from them should be done away with and a fresh start made. "When it is recognised that fatigue is itself not the simple matter it has been considered and that the attitude of the subject towards the test largely determines the result, it will be readily recognised that the search for a single, simple, accurate test of fatigue which can be employed at any time with any number of pupils by a half-trained teacher is a vain quest."

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[1] *Op. cit.* Part IV.

[2] *A study of the present methods of testing fatigue*; Amer. Jour. Psy., 1903, pp. 509 ff.

These facts must be borne in mind in considering the following summary of the various methods which have been used.[1]

1. *The aesthesiometer.* The use of this instrument depends on the fact that the skin becomes less sensitive to pressure when the body is fatigued. Consequently the determination of the least distance at which the two points (blunt compass points form a simple aesthesiometer) can be correctly distinguished has sometimes been taken as a measure of fatigue. The difficulties of avoiding varying pressures and of applying the two points simultaneously militate greatly against its general use.,

2. *The ergograph.* This instrument was invented by Mosso. It is an instrument for automatically recording on a revolving drum the motions made by the flexions of a finger in successively raising a given weight when all other parts of the arm are firmly fixed to a table. The weight is suspended by a string (which has a loop for the finger) running over a frictionless pulley. The objection to the method is that a person when beginning to fatigue may, by sheer will-power, put on a spurt which greatly affects the result.

3. *The dynamometer.* The use of this instrument as a measure of fatigue presupposes that muscular activity can be used as a measure of mental activity. The dynamometer measures the strength of grip in kilograms. Mental fatigue is supposed to decrease the strength of the grip. The instrument has been widely used because of the simplicity of its handling.

4. *The algesimeter.* This instrument measures the sensitivity to pain. A blunt point is pressed into some part of the skin and the pressure needed to give pain is recorded. Most experimenters think that sensitivity to pain increases with fatigue; Binet found it to be less. The question is not yet satisfactorily settled.

5. *The kinematometer.* The kinematometer is a movement measurer. With the elbow as a centre, arcs of circles are swung and the normal swing fixed by stops. After a few moves, one of the stops is removed and the subject makes a movement which feels as big as the normal one.

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[1] For details and classifications consult Offner: *Mental Fatigue*: trans. by G. M. Whipple, 1911, and Claparède: *Experimental Pedagogy*, trans. by Louch and Holman, 1911. These two books give the best up-to-date accounts of the work done on Fatigue.

The error is recorded. Larger errors are made when the subject is fatigued.

6. *The tapping method.* The subject taps for a brief space of time as quickly as possible. The number of taps is smaller when the subject is fatigued. If the tapping is carried on for a considerable period a fatigue curve may be made out.

7. *Reaction time.* The time taken to react to a signal (for example to lift the finger from a pressed telegraph key) is longer when fatigue is present.

8. *The Rhythm method.* The subject is asked to beat upon a telegraph key some rhythm such as three or four beat-measures, and the time taken is recorded on a revolving drum. Since each person has his own individual tempo and fatigue causes it to slow down, the method may be used as a measure of fatigue.

9. *Respiration and Pulse variations.* Both rate of respiration and rate of heart beat are diminished by fatigue, but it has yet to be proved that a relationship exists between them.

10. *Eye accommodation.* During fatigue the range of accommodation—the distance between the far and near points of the eye—is increased and consequently its measurement affords a method of testing fatigue.

11. *Dictations.* With the increase of fatigue the number of words mis-spelled in a piece of dictation, apart from those due to ignorance, increases. This method has been used as a test of fatigue but it is difficult to get tests of uniform difficulty. The method has historical interest since it was the first method employed to test fatigue (Sikorski, 1879).

12. *Calculations.* The ability to do arithmetical computations quickly and accurately is said to decrease as fatigue increases.

13. *Counting letters.* Given letters, say *a*'s and *e*'s, are struck out from a page of print. Fatigue diminishes the number so marked.

14. *Memorising.* Immediate memory is tested by means of a series of numbers which are exposed for a short time. The less the fatigue the better is the memory.

15. *The Completion method.* Prose passages, which are incomplete through the omission of certain words, have to be filled in by the subject. The missing words are difficult to find if he is fatigued.

Other methods. Persistence of visual sensations, hitting at moving dots (McDougall), steadiness, copying, cancellation, attention waves (Pillsbury) and the method of continuous work have all been suggested and used as tests of fatigue.

The Fatigue Curve. A better name for the curve would be the curve of work. This illustrates the manner in which fatigue develops. According to Offner[1] there are well-defined phases in the development of fatigue. In the first place there is a warming up period when the work shows improvement both in quality and quantity. During the second stage the quantity still increases but the quality, as measured by the number of mistakes made, shows a deterioration. In the third stage the quantity shows a gradual decrease. In the fourth stage the rate of decrease is either hastened, or, through a "fatigue intoxication," is spasmodically increased. Both types of fourth stage fatigue are followed by exhaustion and break-down. There are, however, important individual differences in the fatigue-curves of individuals. There are also rhythms in fatigue.

Factors influencing the fatigue curve are age, sex, the type of work performed, the time of day, meteorological conditions, and degree of nutrition of the body.

Thorndike seems to think that pupils can work at any time of the day as well as at any other, but that they do not necessarily do so. As work progresses boredom or repugnance increases, the remedy for which is to make it worth while for the pupil to work during periods of the day. He supports his argument by morning and evening experiments on children in the schools of Cleveland and Scranton. Woodworth's experiments on himself, whereby a series of activities along special lines were continued for excessively long periods, are also mentioned. These activities were—8 hours marking words containing *a* and *t* ; 4 hours memorising numbers ; 3 hours estimating the areas of small parallelograms, correcting examination papers, and compiling bibliographies. No appreciable decrease of ability was found.

Nevertheless the feeling of boredom is a very real thing and it is probably Nature's way of warning us that a rest is necessary. The following curve of freshness for the day, the opposite of fatigue, which shows the average of the introspections of 50 of my students, is a slight contribution to the subject under discussion. Two maximum periods of ability to work are shown. The extreme ends of the curve are not to be judged too seriously as they are due to a few freak cases.

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[1] Offner : *Mental Fatigue* ; pp. 74-77.

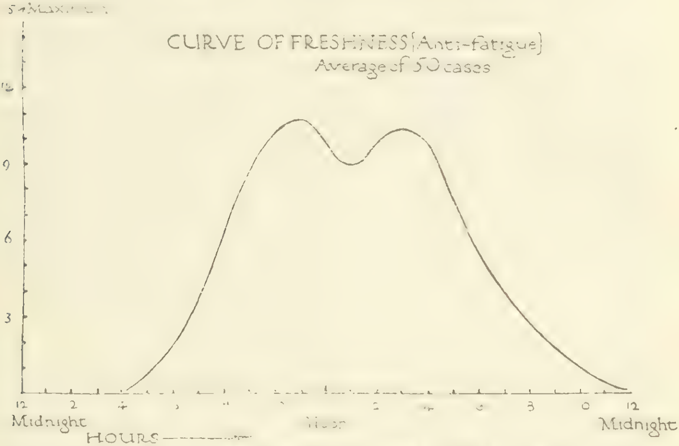

FIG. 27. Curve of Freshness: average for fifty students.

School-work and Fatigue. Certain school subjects produce fatigue sooner than others and various attempts have been made by German psychologists to determine the fatigue-coefficients of the different branches of the curriculum. Wagner, using the aesthesiometer, found in the Gymnasium of Darmstadt[1] that the subjects could be arranged according to difficulty as follows:

Mathematics (the standard)	100
Latin	91
Greek	90
Gymnastics	90
History and Geography	85
French and German	82
Natural History	80
Drawing and Religion	77

His results differ slightly from those of Kemsies (dynamometer), who found that gymnastics was the most fatiguing type of school work.

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[1] *Unterricht und Ermüdung*, Berlin, 1898, p. 131.

Other problems which have been investigated, but up to the present with unsatisfactory results, are (1) the fatigue-coefficients of different teachers, and (2) the fatigue-coefficients of different methods of teaching.

Practice and Fatigue. It will have been gathered from the previous discussion that practice and fatigue are opposed and tend to cancel each other. In the practice-curve we do not measure the true increase of efficiency due to practice, but such increase *minus* an amount due to fatigue. In a similar way in the fatigue-curve we do not measure results due solely to fatigue, but amounts due to fatigue, *plus* an amount due to the familiarisation of practice. How to increase the effects of practice and minimise the effects of fatigue is a standing problem of method in teaching.

METHODS OF LEARNING.

1. Learning by Selection of Successful Variations. This method is popularly termed the "hit and miss" or the "trial and error" method. It consists of the selection out of a number of more or less random movements, of certain successful ones and the rejection of all others. Successful actions are those which bring pleasure by leading on to a desired goal. The method is seen in its simplest form when cats, dogs, monkeys and other animals learn to get into or escape from a specially constructed box to obtain food. The time curve generally shows a gradual descent. Even in those cases where the animals (as in the case of Woodworth's chimpanzee) learn almost immediately, there is certainly no reasoning about the matter. If there were, then two bolts would be no more a hindrance than one. The more varied the reaction of an animal in a given situation and the greater the appreciation of success, the sooner does this method lead to success.

This method, in a more refined way, plays a great part in human learning. Most of the habits of young children are learnt almost exclusively by this method, and that it does not always disappear with age is shown by the way we attack mechanical puzzles and jig-saw problems. Other elements are of course present and complicate matters, but there is a fair proportion of blind hit and miss about most of the habits we learn. The greater variation of reactions to a single stimulus is at bottom the basis of the educability of human beings by this method.

2. Learning by Imitation. The Earl, in "The Admirable Crichton," when stranded on the desert island, was profoundly grieved when his belief in the imitativeness of monkeys received such great shocks. Experimental evidence (Thorndike, Kinnaman and Hobhouse) confirms Barrie's statement. Yet imitation in children is notorious, and is one of the chief methods of learning. Much of the learning is by unconscious imitation ; a much smaller part than is generally supposed is played by direct or conscious imitation. Further, children imitate actions—the description of an action, owing to lack of command over language and of a store of knowledge from which to draw, is seldom effective as a means of arousing imitative actions.

3. Learning by Ideas. All our higher or more complicated knowledge is acquired through the medium of ideas. The solving of mathematical problems and the thinking out of the political bearings of Acts of Parliament are performed by the use of ideas. There is, however, less thinking out of problems to ultimate conclusions than is generally supposed. The method of learning by ideas overlaps in bewildering fashion the other main method of learning. It is also bound up with the greater powers of association, analysis, and discrimination which man possesses. Locks and combinations of fastenings which completely defy monkeys, cats and dogs, are easily overcome by man because the situations receive a more complete analysis. The analysis of more complex situations, such as are met with in mechanical puzzles or problems of geometry, sometimes proves too difficult, and recourse to more elementary methods of learning is made. The first act of thinking, which is a method of learning by ideas, is the recognition and segregation of the problem in hand. Intellectual power is based upon this fundamental property of mind.

GROWTH OF MOTOR POWER AND CONTROL IN CHILDREN.

A child at birth has practically no control over any of his muscles except those connected with grasping and sucking. As time passes both power and control develop. This development is due to an increase of size and efficiency of the muscles and to the co-ordination of neurones of the nervous system with which they are connected.

In general, the more fundamental muscles develop first, the accessory ones later. Stating it in the form of a law we may say that "the wave of development proceeds outwards towards the extremities," that is, the coarser muscles of the body, arms and legs develop earlier than the finer ones. The muscles of the shoulder and the upper arm become functionally active before those of the lower arm, wrist and hand. This is not strictly true, for the accessory muscles of the hand and feet which enable a child to grasp are, as we have seen, functionally active soon after birth. But in the main the generalisation is correct.

Motor power is complex: it may refer to voluntary control, the rate of movement, the variety of movement and the actual strength of the muscles.

Experiments. W. L. Bryan[1] worked out the development of the rate of tapping of the shoulder, elbow, wrist and finger for 789 school children between the ages of 6 and 16 years. The arrangements of the arm for tapping were (1) For shoulder. The forearm was at right angles to the upper arm; the elbow was placed over the tapping key and the swing was in a vertical plane. (2) Elbow. Elbow rested on the table; the forearm was at right angles to upper arm; the key was struck by the ventral side of forearm just back of the wrist. (3) Wrist. Elbow rested on the table; the forearm was clamped just above the wrist and the key was struck with the palm of the hand. (4) Finger. The metacarpo-phalangeal joint of the forefinger was used; the palm was held with moderate firmness at 135° to the forearm.

Between the ages of 6 and 16 years the following total increases of x taps in 5″ were observed:

	Finger.	Wrist.	Elbow.	Shoulder.
Boy's right,	14·4	12·9	9·2	8·9
,, left,	12·7	13·3	10·3	8·4
Girl's right,	11·5	8·5*	7·4*	8 0
,, left,	10·6	10·6	8·5*	8·3

*Higher at 13 than at 16.

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[1] *On the development of voluntary Motor Ability*; Amer. Jour. Psy., V., pp. 125-204.

The results show that the finger improves most and it is followed by the wrist, elbow and shoulder in the order named. The wave, therefore, passes outward, for that which improves most must have been least developed at the beginning. The right hand shows greater development than the left, and boys show more than girls.

Bolton [1] found that brighter children increase in motor power with advancing age. So also do backward children, but the improvement is not so great. Lack of mental alertness is accompanied by a deficiency in motor power. "There is greater rapidity of motion, increased steadiness and nicer precision, the older the children grow."

The following table by Hastings [2] shows the development of strength of the arms of children (5,576 cases) between the ages of 5 and 16:

TABLE 26.

Age.	Strength of Forearm, r. kilos.	Strength of Forearm, l. kilos.
5	4·89	4·72
6	6·98	5·70
7	9·18	8 53
8	10·63	9·53
9	13·14	11·77
10	14·74	14·06
11	18·02	16·11
12	19·68	18·44
13	22·59	20·49
14	25·37	23·05
15	28·85	24·68
16	33·31	29·64

The facts brought out by these and similar experiments indicate the necessity for framing school tasks commensurate with the developing motor power and control of the scholars. To give children of the lower standards fine sewing and delicate tasks of manipulation to do, is not only wasteful but in the light of recent research, almost criminal. We must await the optimal times of development and then strike hard, " while the iron is hot."

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[1] *The relation of motor power to intelligence*; Amer. Jour. Psy., XIV., pp. 615-631.

[2] Quoted by Stanley Hall: *Adolescence*, I., p. 135, in a valuable chapter on "Growth of Motor Power and Function."

References. Andrews: *Habit*; Amer. Jour. of Psy., Vol. XIV., pp. 121-149. Angell and Coover: *General Practice Effect of Special Exercise*; Amer. Jour. Psy., July, 1907. Bagley: *The Psychology of School Practice*; Psy. Bull., March, 1909. Bair: *The Practice Curve*; Psy. Rev. Mon. Suppl., No. 10 (1902), pp. 1-70. Bawdon: *Study of Lapses*; Psy. Rev. Mon. Suppl., Vol. III., No. 4, pp. 1-122. Bryan and Harter: *Studies in the Telegraphic Language*; Psy. Rev., Vol. VI. (1899). Bolton: *Relation of Motor Power to Intelligence*; Amer. Jour. of Psy., Vol. XIV., pp. 622-631. Claparède: *Experimental Pedagogy*. Cole: *Concerning the Intelligence of Raccoons*; Jour. of Compar. Neurol. and Psy., Vol. XVII., pp. 211-261. Cornman: *Spelling in the Elementary School*. Drummond: *The Child*; Chap. XI. Findlay: *Principles of Class Teaching*; Chap. XIV. Groos: *The Play of Animals*. Hall: *Adolescence*; Chap. III. Heck: *Mental Discipline*; Chap. on Experiment. James: *Principles of Psychology*. Judd: *Genetic Psychology*; p. 161. Kirkpatrick: *Fundamentals of Child Study*; Chaps. V. and XVII. Ladd and Woodworth: *Elements of Physiological Psychology*; Chaps. VII. and VIII. McDougall: *Physiological Psychology*; Chaps. II. and VIII. Mumford: *Dawn of Character*; Chaps. V., VI. and appendix. Myers: *Experimental Psychology*; Chaps. III. and VI. Offner: *Mental Fatigue*; tr. Whipple (contains an excellent Bibliography). Rowe: *Habit Formation and the Science of Teaching* (contains an annotated Bibliography). Stout: *Manual of Psychology*; pp. 284-287. Swift: *Mind in the Making*; Chap. VI. Thorndike: *Effect of Practice in a case of a Purely Intellectual Function*; Amer. Jour. of Psy., July, 1908. Thorndike: *Elements of Psychology*. Thorndike: *Mental Fatigue*; Psy. Rev., VII., 6. Thorndike: *Principles of Class Teaching*; Chaps. VII. and VIII. Thorndike: *Notes on Child Study*; Chap. VI. Thorndike: *Human Nature Club*; Chap. III. Thorndike: *Animal Intelligence*. Titchener: *Primer of Psychology*; Chap. IX. Wimms: *The Relative Effects of Fatigue and Practice produced by different Kinds of Mental Work*; Brit. Jour. of Psy., 1907. Woodworth: *Accuracy* *of Voluntary Movement* ; Psy. Rev. Mon. Suppl., Vol III., No. 13, 1899, pp. 1-114. Welton : *Psychology of Education* ; Chaps. IX. and X. Whipple : *Manual of Mental and Physical Tests.* Yerkes : *The Dancing Mouse.* Yerkes and Huggins : *Habit-Formation in the Crayfish* : Psy. Rev. Mon. Suppl., Vol. IV., pp. 565-577.

CHAPTER X.

ASSOCIATION.

I TELL the students of my class to write down whatever thoughts come "into their heads" in consequence of my pronouncing a certain word. I then say "blue" and await results. One of them, I find, immediately thinks of the blue sky; then of the blue sea; of Blackpool; and of a holiday spent there. A second thinks of a blue dress, of a concert where the blue dress was worn, of violin playing, of music as a form of art; of paintings; of Rembrandt; of Holland; of Denmark; and of butter making. All agree that the ideas come so quickly that they are unable to record them all, but they also find that "one idea suggests another," that a certain relationship between the most diverse of topics is discoverable. This observable relationship between the contents of consciousness is called association. Formerly the term "association of ideas" was given to it, but James pointed out that it is things, not ideas, which are associated in the mind. If under "things" we include sense-qualities as well as concrete objects, the statement is fairly true to facts.

Herbartian Explanation of Association. To Herbart and his disciples we must give credit for first announcing a consistent explanation of the phenomena of association and applying it to school-room procedure.[1] According to them ideas exist as separate entities and are dynamic in character. Consciousness is imagined as a sort of beehive-shaped dome in which ideas move about with great freedom. The ideas which reach the summit of the dome are in the focus of consciousness while others within the dome form the margin of consciousness. The bulk of the ideas, are, however, beneath the floor of the dome or, as they describe it, beneath the threshold of consciousness. A continuous interchange takes place between ideas above and below the threshold, and between those in the focus and those in the margin of consciousness. Similar ideas may fuse together and form groups known as apperception-masses. The bigger the group, the greater is its chance of rising above the threshold and of reaching the summit of the dome. A single unconnected idea seldom reaches the focus. The one factor which enables it to survive is its fusion with some other idea or group of ideas already existing in the mind. But it probably remains for ever beneath the threshold unless it has friendly ideas at court.

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[1] Adams: *The Herbartian Psychology applied to Education*; 1898. One of the few really humorous treatises on Education.

The explanation is extremely suggestive and has been very fruitful in practice. It explains why we must fuse new knowledge on to old; and why everything new must be learnt in terms of the old. But it is false in its fundamental assumptions. Ideas are neither dynamic nor are they capable of a separate existence.

Physical Basis of Association. The explanation of association must be sought in the structure and properties of the neurones composing the nervous system. That this is so, is recognised by metaphysical psychologists such as Stout, who says "Association is an acquired psychophysical connection between psychophysical dispositions or between a psychophysical disposition and a purely physiological arrangement. This second alternative is very important. It includes all cases of what may be called 'motor association.' The sight of a word may prompt me to pronounce it, as in reading aloud. This is due to a previously acquired connection between the psychophysical disposition excited by the sight of the word and the special nervous and muscular arrangements for producing the movements of articulation. Motor associations are, as we shall see, of immense importance in our mental life—especially at the perceptual level. Learning to walk, to shoot, to fence, in general the acquirement of bodily aptitudes and dexterities, depends on the forming of appropriate motor associations."[1]

But why, and in what manner, does the neurone system involved in the visual perception of a man become connected with the neurone system employed in hearing his name? The two systems are quite distinct and yet they become so fused together that it is almost impossible not to name an individual as soon as he is seen. McDougall[1] thinks that neural drainage explains it. "When the excitement of one neural system *a* is immediately followed by the excitement of another *b*, the free nervous energy of the former system *a* tends to discharge itself by some path into the other system *b*. This might be called, for reasons we shall consider presently, the law of the attraction of the impulse. If when *a* and *b* are first excited in immediate succession, such a discharge from *a* to *b* takes place, then, in accordance with the law of neural habit, the path by which the discharge takes place will become a path of lowered resistance, and whenever *a* is re-excited in any way there will be a tendency for the excitement to spread through the path to *b*. . . . We may liken these systems of neurones to india-rubber tubes arranged vertically and freely connected by transversely running tubes. They are all closed at their lower ends by spring valves, and all are partially distended with water at a certain pressure insufficient to open the valves. This low pressure throughout the system represents the tone of the neurones. If then the pressure in one tube *a* is suddenly increased by injecting into it at its upper end an additional quantity of water, a wave of pressure will travel down the tube, throw open the valve at its lowered end, and water will flow down and out of the tube. If in the next moment while this flow is taking place and the pressure is not yet equalised in the system, a similar sudden increase of pressure is caused in any one of the other tubes *b*, throwing freely open its valve, currents will set towards this tube through all the transverse tubes in virtue of the tension or tonus of the whole system, but the main flow will be through those transverse tubes which form the most direct path between *a* and *b*, and this current, relieving the tension in *a*, will result in its spring-valve closing up. The flow through *b* will thus inhibit by drainage the flow from *a*."

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[1] Stout: *The Groundwork of Psychology*; p. 61.

M'Dougall's theory of drainage is criticised by Ladd and Woodworth[2] who point out that in the case of the visual impression and the name of a man there is not that complete drainage which the theory requires ; "the face does not disappear when the name is spoken." In formulating a new theory they suppose that after a discharge of energy has taken place through a neurone system its activity does not come to an abrupt end ; it is, in fact, left in a condition of heightened excitability. If therefore two contiguous systems are stimulated simultaneously or in quick succession they of necessity connect up because " each has something to give, and each is ready to take." With the further elaboration of the theory to explain the formation of higher units we need not concern ourselves. We are seeking an explanation of the first association path.

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[1] *Physiological Psychology* ; p. 124 ff.

[2] *Elements of Physiological Psychology* ; p. 617 ff.

Unfortunately for this theory the heightened excitability of the nervous system after the passage of an impulse remains to be proven. Most probably fatigue effects, for a brief space of time, lessen, rather than heighten the excitability of the system.

The following theory is put forward tentatively. It does not seem to make as many assumptions as the previous ones. We have seen that the following facts are those on which a rational explanation of psychological phenomena has been built, namely : (1) the more closely associated two neurone systems are by the inner growth of the body, the more easily do they function together ; (2) neurones, except after immediate discharge, are in a state of tension (*i.e.* exhibit a tendency to discharge) ; (3) the discharge always takes the path of the least resistance ; (4) the stronger the stimulus the wider is the area affected by it ; (5) the passage of an impulse through a neurone system permanently lowers its resistance.

Consider the neurone systems *a* or *b* which are fairly closely associated by growth but not yet definitely connected. Both are in a state of tonus and ready to discharge into as many contiguous systems as possible. Suppose them stimulated simultaneously or in immediate succession. Both systems seek an outlet. Under these conditions they are more than likely to discharge through a system *c* which is common to both. This common channel of discharge causes the association of *a* and *b*, for when *a* is next stimulated its discharge through *c* lowers, for an instant, the resistance between *b* and *c* and so *b* also discharges. The stronger the initial discharges, the closer the association between *a* and *b*. Thus the element of vividness in association is explained. Recency, frequency and the other factors are also easily explained by the theory, The failure of an association to take place can be accounted for by supposing that stimulation of *a* and its discharge through *c* is insufficient to break down the natural resistance existing between *b* and *c* when both are quiescent. It explains why association is, as a rule, in a forward direction but it does not give a satisfactory explanation of backward association: neither, for that matter, does the drainage theory nor the heightened excitability theory. Backward associations are probably forward associations taken in minute pieces at a time. Simultaneous and successive associations are especially easy to explain on this theory. In fact, it gives a physiological explanation of that great factor in all association—temporal contiguity. If we elaborate the units, *a*, *b*, and *c*, into complex systems connected up with other systems in a thousand and one different ways we begin to appreciate the wonderful possibilities of the nervous system so far as association is concerned.

The conception of a common channel of discharge for two or more systems receives encouragement from the presence of association fibres in the brain and spinal cord. Extirpation of association areas of the brain, for example, destroys the ability to perform acts necessitating association (see Chapter IX.). Such areas have usually been looked upon as connecting areas, but part of their function may well be to provide common paths of discharge between areas distantly removed.

The Number of Associations. The number of associations formed depends upon the inherent structure of the nervous system and the amount of exercise it has had. We saw that some tricks were beyond the most intelligent of monkeys and this failure must be attributed to an insufficient elaboration of their nervous systems. In just the same way a defective inheritance in this respect prevents an idiot, an imbecile or a mental defective from ever forming as elaborate associations as a normal person. A genius is distinguished from an ordinary individual mainly by the number and complexity of his associations. It is as if a single stimulus spread through scores of neurone systems.

Galton tried to discover the number and nature of his associations. He took a walk along Pall Mall and faithfully recorded the associations each object aroused. He was astonished at the variety and complexity of them. No part of his life seemed to have been forgotten. But in repeating the walk shortly afterwards he noticed that the associations of the previous occasion were in many cases repeated. "The actors in my mental stage were indeed very numerous, but by no means so numerous as I had imagined. They now seemed to be something like the actors in theatres where large processions are represented, who march off one side of the stage, and, going round by the back, come on again at the other."[1]

Rapidity of Associations. The rapidity of our associations depends upon the degree of our familiarity with them. It is more difficult to name the month preceding a given month, or the letter of the alphabet preceding a given letter than it is to name the succeeding ones, because the forward direction is the more familiar one. Likewise a foreign language is more slowly perceived than one's native tongue. Cattell experimenting upon himself, found that, reading as quickly as possible, the following times, given in thousandths of a second, were necessary for the perception of each word: English 138, French 167, German 250, Italian 327, Latin 434 and Greek 484. But why it should take less time to pass from a part to a whole than from a whole to a part seems difficult of explanation. In the same way various experimenters have found that it is as easy to read four-letter words as single letters. Perception of words, therefore, is not by means of the single letters composing them; larger units must be employed. Of single letters "e" is the most difficult to recognise, "w" the easiest.[2]

Factors involved in Association.[3] The factors usually given are 1 frequency, 2 recency, vividness, primacy, the 5 resultant satisfaction, 6 the mood of the moment and the 7 relationship existing between the objects associated. (*a*) *Frequency*. The more frequently two objects are associated the easier becomes the process. It is difficult to think of the discovery of America without recalling the name of Columbus; 9×7 is associated with 63; and "Humpty dumpty" is invariably associated with "Sat on a wall." Repetition or frequency is the chief cause of the association. These things have occurred so often together in our experience that it is only with the utmost difficulty that we can now dissociate them. Drill or practice in school-work receives its sanction from this principle. (*b*) *Recency.* The traces left behind in our nervous system by events of to-day are deeper than those of a year ago. It is fairly easy to recall the drift of yesterday's sermon in church but the sermon of a month ago seems entirely to have disappeared. And so with other things. Teachers have recapitulatory lessons because children forget the past so easily. They invoke the power both of frequency and recency to aid them in making clear associations in the minds of their pupils. (*c*) *Vividness.* Some sermons, because of the vividness of their presentation, make a deeper impression than others. Hence vividness is an important factor in association. "I shall never forget it until my dying day" refers to some particular vivid association. The reason children learn more quickly from one teacher than another is partly by reason of the vividness of presentation. But we must remember that vividness is a relative term. In order that mountains may appear high we must have the contrast of deep valleys. (*d*) *Primacy.* "First impressions are strongest." The writer kept diaries during his first visits to Denmark and Germany and is often amused at the things which were eagerly noted upon arrival. But amusing and irrelevant as some of the observations were, they colour all subsequent impressions, and deeper knowledge fails to oust them from their place of honour. First impressions of the theatre are often most influential partly because of the vividness of the occasion, but also because of their primacy. If on our first introduction to a volcano the idea of a burning mountain is associated with it, the connection persists in a most troublesome manner; sometimes years of teaching fail to dispel the incorrect information. Primacy has played its part well. (*e*) *The resultant satisfaction.* The normal human mind loves to dwell on the pleasant things in life and shuns the contemplation of the unpleasant. "The dead are soon forgotten." Those situations which resulted in satisfaction at the time of their occurrence stand a much better chance of becoming associated than others. The importance of this great law is not sufficiently emphasised in school-room practice. And it is often forgotten tha the satisfaction which comes from completing a hard task is one of the great and pure satisfactions of this life. (*f*) *The mood of the moment.* If we are in a despondent mood our whole outlook is tinged with despondency. Dismal associations are aroused by stimuli, which, on other days, would have aroused nothing but pleasant thoughts. These moods are valuable signs of bodily health. With a good digestion and with plenty of sleep and healthy exercise it is almost impossible to be pessimistic. (*g*) *The relationship existing between the objects.* In the parlour game where a tray containing thirty or forty different objects is shown to us for a short time and we are told to name as many as we can remember, we try to make artificial associations. It is, however, a difficult task. Where the relationship between objects is slight or non-existent, associations are only formed after great exertion; where natural relationships exist associations are easily formed. In systems of memory training the whole object is to make the subject dwell upon the problem and construct artificial associations. The various number rhymes and number games are excellent examples of this principle of relationship; in these cases artificial relationships are deliberately established.

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[1] Galton: *Inquiries into Human Faculty*; p. 135.

[2] See Cattell: Wundt's Philos. Stud., 1888, IV., 241, and Mind, XII., 68.

[3] See also Chapter XI. on Memory.

The Law of Association. Thorndike combines most of the previous principles of association into one law. "Any fact thought of will call up that fact, the thought of which has accompanied or followed it or a part of it most frequently, most recently, in the most vivid experience and with the most resultant satisfaction, and which is most closely connected with the general set of mind at the time." [1]

Number-forms.[2] Another peculiarity of associations is that in some people they assume definite spatial relationships one with another. The most common form of spatial associations is that of the number-form. In these cases numbers when thought of always assume a definite position on a line, which is generally a zig-zag in shape. Arithmetical operations are done by jumping with marvellous rapidity from one place to another on this line. Later introspections have shown forms for other things. Thus the writer places the months of the year on an egg-shaped figure with December and January at the narrow end, and June, July,

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[1] *Elements of Psychology*; p. 249.

[2] See Galton: *Inquiries into Human Faculty*; p. 79 ff., for a discussion on this topic.

August and September at the broad end. The hours of the day and days of the week associate themselves in other complex forms. The reason for these forms is still unknown. The clock face certainly influences many of them. Colour associations are also known but they are far less numerous than number forms.

Mental Diagnosis by Associations. So intimate are our associations that "we give ourselves away" if we subject ourselves to test. The following is a description of such an experiment.[1] Two boxes were prepared, containing in the first experiment a bottle of red ink and a watch, and in the second, a toy snake and a pack of cards. Fifty-three students were told to go and look in one of the boxes, and on returning to try to prevent the experimenter from finding out into which box she had looked. Reaction times to sixty exhibited words were then taken with a stop-watch. Each subject was told to give the first associated word that occurred to her. Ten of the sixty words referred to the contents of one box and ten to the other. The relevant words were scattered among the others, but three or four were given in immediate succession to increase the disturbing effect on the observer. The first word called up in connection with relevant words was likely to be associated with the objects in the box; if this word was kept back and a second one substituted there would be an increased time of reaction.

By judging of associated words and the times taken, one experimenter gave 52 judgments out of 53 correctly. The other experimenter using only the character of the associated word gave 34 correct judgments.

This experiment, while probably of greater use in the police court than in the school-room, shows the great influence that recency has on our associations.

Association Tests.[2] These tests are usually divided into tests of (1) uncontrolled association and (2) controlled association.

(1) The *uncontrolled association* test consists of the subjects writing (or saying) a given number of words as quickly as possible. Any type of words may be written;

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[1] Leach and Washburn: *Some tests by the association reaction method of mental diagnosis*; Amer. Jour. Psy., XXI., pp. 163-167, 1910.

[2] Whipple: *Manual of Mental and Physical Tests*; Chap. IX.

words forming sentences are, however, debarred. The results of these associations show that the words often follow a series of themes or some auditory sequences. They also show that in a given community of students the same word occurs in different papers with surprising frequency. "Jastrow found that in 50 lists (5,000 words) only 2,024 words were different, only 1,266 words occurred but once, while the hundred most frequent words made up three-tenths of the whole number."[1] Jastrow also found that the thinking of the association between one word and the next occupied, on the average, ·96 seconds. Women are said to use, in tests of uncontrolled association, more names of wearing apparel and a less number of abstract terms than men. The results are, however, indefinite.

(2) *Controlled association* tests are of four kinds—part-wholes, genus-species, opposites and computations.

In the *part-wholes* test the pupils are given a list of ten words and then are asked to write the name of a whole thing of which the word given is a part. The time taken is recorded. "Book," for example, would be the whole of which "page" is a part. The following words have been used :

1. door.
2. pillow.
3. letter.
4. button.
5. leaf.
6. nose.
7. cover.
8. page.
9. engine.
10. glass.

In the *genus-species* test some particular example must be written of which the name given is the class. If "verb" is the class, "run" would be a particular example ; "book" as a class could be followed by the title of any book as the particular example. The words which have been used are :

1. book.
2. room.
3. name.
4. boat.
5. plant.
6. tree.
7. tree.
8. dish.
9. game.
10. fish.

In the *opposites* tests the subjects are told to write words which mean the exact opposite of the ones given. If "bad" is given then "good" would be its exact opposite. Three lists which have been used are given below :

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[1] *Loc. cit.*, p. 316.

bad	good	stupid	dislike	like	rapid
inside	outside	hardworking	poor	rich	generous
slow	quick	strong	well	sick	straight
short	tall	sane	sorry	glad	separate
little	big	obnoxious	thick	thin	up
soft	hard	foolish	full	empty	always
black	white	handsome	peace	war	joy
dark	light	adroit	few	many	high
sad	happy	superior	below	above	obscure
true	false	loquacious	enemy	friend	proud

In *computations* the elementary arithmetical processes of addition, subtraction, multiplication and division are used. The time taken and the errors made are noted as in the other controlled association tests. Whipple (p. 329) gives the following lists of examples of materials which have been used in computation tests :

A.
2
6
9
7
4
8
9
5
1
7
5
2
6
3
5
1
3
9
2
1
3
6
9
8
3
5
2
7
6
2

B.
4
1
3
5
2
6
4
3
4
6
1
5
4
2
1
2
3
6
5
3
6
5
1
2

C. 4 2 8 3 2 9 9 5 4 6 5 4 3 1 7
7 9 2 9 3 8 3 8 2 6 5 5 1 3 9
1 1 0 2 etc.

D.
95799
86967
32687
84799
95976
34797
97864
98945
87824
68792
79867
88896
97745
39799
48970
89043
67354
54628
91176
90256

E. 42
+79

F. 492
+763

G. 93
68
41
25
52

H. 6429364319483145762 7
3868272542358579185 8

I. 982
−469

J. 64
− 2

K. 28
× 8

L. 364
× 6

M. 47
89

N. 948
× 579

O. 7986
× 4523

P. 4284239954792533143 25
× 4

Q. 254) 4659234 (

R. 4) 799

In conclusion it may be said that association tests are fairly good measures of the intelligence of pupils; and that the computation tests may also be used in making fatigue and practice curves.

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CHAPTER XI.

MEMORY.

Memory, Association and Habit. So closely are these three aspects of mental life bound up with one another that one recent writer on Psychology deals with all three in one chapter on Memory.[1] That the physiological basis offers a reasonable explanation of many mental phenomena we have insisted upon throughout this entire work and in this case also the contention holds good. We have seen that processes occurring in the central nervous system leave an impression or trace, by means of which, under appropriate circumstances, they may be reproduced. When discharges regularly take place along certain paths we get the phenomena of habit; when one neurone system is aroused to activity by means of the stimulation of another the process is known as association; while the stimulation of a neurone system which leads to the revival of a previous experience in imagination, and with the additional knowledge that we have experienced it before, produces the phenomenon we call memory. This particular kind of memory has been called associative memory because it depends on association. And from this point of view also, habit may be looked upon as unconscious memory.

The two aspects of memory emphasised by our definition are retentiveness and recall. While the neurones are quiescent we get retentiveness—a primitive property of nerve tissue; during activity we get recall. The retentiveness, however, is not of the same character as that of a phonograph record which reproduces over and over again the original cause of the impression. The impressions upon the nerve substance fade away with time; and only the essential elements, or relevant facts and meanings are capable of recall.

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[1] Dumville: *Fundamentals of Psychology*; 1912.

Types of Memories. There are very great individual differences in memory. Cases are known where memory is almost perfect over long intervals of time, and examples of almost complete absence of associative memory are quite common. Memory also is highly specialised. We talk about good and bad memories, about logical and rote memories, about concrete and abstract memories, about immediate and persistent memories, and about such special memories as those for objects, numbers, sounds, abstract terms, emotions and ideas. There are, in fact, as many kinds of memories as there are modes of representation. "As memory consists of the power of ideal revival, there must be a relatively separate memory for every experience ideally revived. There must not only be a separate memory for names, but a separate memory for each peculiar name. But ordinary language is undoubtedly right in recognising distinct memories for general departments of experience."[1]

(*a*) *Good and bad memories.* By a good memory is meant a memory that serves us well. The goodness of memory depends upon the persistence of impressions, the number of the associations formed and the readiness and appropriateness of recall. Perhaps the best memory on record was that of a mental defective who could recite whole books when once the cue was given, but it was not a good memory in the sense in which we have defined it, namely, one which is serviceable and useful. Mrs. Nickleby had a prodigious memory but it was a bad one because she had no desultory memory; she could not forget irrelevant facts. And the memory of the M.P. described by Dr. Carpenter was also a bad one. It is recorded of him that he could repeat long Acts of Parliament after once reading and that he experienced great inconvenience during his speeches, for, when referring to those Acts, he could not briefly refer to their contents but must needs quote the whole section just as it stood and often indeed the whole Act. Such a person was probably damaged intellectually by his memory, which would certainly destroy any aptitude for hard thinking.

Generally speaking, however, the more persistent memory is, the better it will be. The actor belonging to a repertory theatre or stock company must perforce have a persistent memory or he will have to re-learn his part each time a play is produced. But the cases which come before a barrister need only be remembered for a short space of time ; they are never repeated and so it is a help if the details can be forgotten. And so with other things. Most of our information needs to be remembered but some of it requires jettisoning because it will never be useful again. Of what use can the small talk of the "At Home" day be to any of us ? The degree of persistence of memory depends partly on congenital equipment and partly on the degree of interest it aroused at the time of its acquirement. Schoolboys remember football results, women remember the cut and colour of clothes, and business men remember prices with an accuracy which is quite bewildering to the uninitiated. Certain pieces of information again are inherently more interesting than others and so we find school children remembering about the burnt cakes while forgetting completely all other facts connected with Alfred.

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[1] Stout: *Manual of Psychology*; p. 460.

The number of associations formed is also an important factor in memory. By continuous study of a subject all kinds of associations weave themselves around it, while cramming up the same topic for examination may be serviceable for a short time but the information acquired is fugitive—few associations have been formed. Repetition and concentration of attention are factors in forming numerous and persistent associations.

Lastly in a good memory there must be appropriate and easy recall. If as a result of a discussion on spring flowers we wish to recall Wordsworth's poem—"The daffodils" —it would be worse than useless to remember how many thousand bunches of daffodils are shipped from the Scilly Isles to London each spring. The recall in this case would be inappropriate. We see, in examinations, the need of easy recall. Many persons leave the examination room and then discover what simple things they missed. Such persons react with difficulty to situations. But many situations in life demand prompt action. The medical student who was asked by an examiner what he would do if a patient in his presence swallowed a large dose of poison, was justly failed when no answer was forthcoming at the end of three minutes, "because," he was told, "the patient is now dead." And how many of us think of the clever repartee just a few seconds too late!

(*b*) *Logical and rote memories.* By logical memory is meant the memory for ideas. Rote memory connotes the power to reproduce in exact serial form or to repeat by heart. These forms of memory are interesting because experiments on the possibility of training rote and logical memory began with the assertion of James that "all improvement of memory consists then, in the improvement of one's habitual methods of recording facts."[1] James for eight successive days learned 158 lines of Victor Hugo's "Satyr." The time required was $131\frac{5}{6}$ minutes. He next learned the whole of the first book of "Paradise Lost" in twenty-odd minute periods during 38 days. Testing himself on another 158 lines of "Satyr" he found that $151\frac{1}{2}$ were needed—a longer time than before. Similar results were obtained by Burnham, Brown, Baldwin and Pease, and so James concluded that we are endowed by nature with definite qualities of memory and that we cannot improve them by practice.

Ebert and Meumann[2] tested children in the schools of Zürich with nonsense syllables, stanzas, prose sentences, numbers, letters, visual signs, vocabularies, and disconnected words. They found that practice was valuable so long as the materials memorised were sufficiently alike. This would lead to the conclusion that rote memory can be trained but logical memory cannot. Such a result fits in with common experience. Actors learn more quickly with practice, but whether this is actually due to an improvement in memory or in the methods of memorising is not yet determined.[3] And so with logical memory. Although it is very improbable that we train it *as memory*, our association systems function more effectively the older we grow.

In a careful study of logical memory in school children Henderson[4] found that it improved with age. The method employed was to give certain passages (three) of connected prose matter to be learned and then to have it reproduced after definite intervals. A careful comparison of the successive reproductions with each other and with the original was then made with the object of finding out both the amount and the character of the material retained on each occasion. Five passages were taken. The classes tested were from the Public Elementary School, from the High School, and from the University. The plan of operation was to give one of the selected passages of prose to each member of a class and ask him to memorise as much as possible in three minutes. They were told that there was plenty of time ; they could easily read it through twice and then could follow what plan they liked. They were also told that a written reproduction would be called for and that if the exact words had been forgotten the idea was to be put down. Further reproductions were required at the end of two days and four weeks. In the latter case the words they were sure of were to be underlined. The system of scoring was to give marks for the number of ideas, topics, sub-topics, details and words. The rate of learning increased and the rate of forgetting decreased with age, chiefly because older children have better understanding and know how to attack the problem better. Those who learned quickest retained best.[1]

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[1] *Psychology*; I., p. 667.

[2] Ebert and Meumann: *Archiv für die Gesammte Psychologie*; IV. Band, 1 und 2 Heft, 1904, pp. 1-232.

[3] See Fracker, Psy. Rev. Mono. Suppl., 38, 1908, p. 56.

[4] *A Study of Memory for connected trains of thought*; Psy. Rev. Suppl., 1903, pp. 94.

A single reading with concentrated attention was better for immediate reproduction than 3 minutes of study, but longer periods were necessary to fix absolutely ideas and words. In the later renderings details were missed out and there was a decided simplification and condensation.

(*c*) *Immediate and persistent memories.* We have seen that " Easy come, easy go " and " Quickly learnt, quickly forgotten " are, for the general run of persons, quite untrue. Yet undoubtedly there are exceptions. The steady plodder with a bull-dog tenacity may get hold of things very slowly but they may also stick. And some people, as we saw in the case of the barrister, may have to develop the " easy come, easy go " type of memory. So far as facts go one would always choose the quick learner as more likely to do well in later life, for rapidity of learning probably has its basis in a better congenital mental equipment.

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[1] This is at variance with the popular view of memory ; it is " quick and sure," not " slow and sure." Scores of other tests have reached the same result, so that we may now accept it as proven.

(*d*) *Special memories.* Some people think and remember predominantly in visual images while others may habitually use auditory or motor images. Our dominant images largely determine our memories for special things. A person with vivid auditory images will be able to recall tunes well, while one with good powers of visualisation will be successful in recalling to mind such things as paintings, distant places and scenery.

Memory in School Children. Most of the investigators who have worked on the memory powers of school children have used tests for immediate memory. A certain number of objects were shown, or a certain number of nonsense syllables or digits were dictated, and the children were asked to repeat or write them immediately afterwards. The results obtained are somewhat conflicting as can be seen from the following tables :

TABLE 27.

(From T. L. Bolton : *The Growth of Memory in School Children* ; Amer. Jour. Psy., IV., pp. 362-380. Digits were dictated at intervals of two-fifths of a second and the children then wrote the digits as they remembered them. Percentage errors in different grades and at different ages are shown.)

No. of Digits.	8 yrs.	9 yrs.	10 yrs.	11 yrs.	12 yrs.	13 yrs.	14 yrs.	15 yrs.
5	20	14·5	12	9·3	7·4	6·6	4·6	..
6	56·3	45·5	42·5	32·4	31·3	27·7	23·5	25·3
7	78	64·6	66·2	62·5	51·5	49·2	36·1	40·7
8	..	..	..	84	73·7	70·5	65·5	66·2

No. of Digits.	3rd.	4th.	5th.	6th.	7th.	8th.	9th.	High School.
5	21·3	6·1	8·4	6·5	1·6	..	..	..
6	63	39·9	43	32	16·7	16·6	16·5	9
7	87·7	63·3	67	59	46·4	44·5	32·5	50
8	..	..	..	85	57·5	70	64·8	67

TABLE 28.

(From Pohlmann: *Experimentelle Beiträge zur Lehre vom Gedächtniss*, Berlin, 1906, pp. 191. Various kinds of materials were used. The results show the net efficiency of memory at various ages.)

Age.	9	10	11	12	13	14	15	16	17	18	19	20
Average capacity.	39·4	41·4	55·7	59·1	62·1	68·9	55·3	62·9	58·6	58·0	65·4	68·3

TABLE 29.

(From Smedley: *Report from the Department of Child-study and Pedagogic Investigation of Chicago*: U.S. Comm. Reports, 1902, I., 1115-1138. Digits were used and presented in two ways. The per cent. remembered is shown.)

Age.	No. Tested.	Auditory Presentation.	Visual Presentation.
7·7	19	36·4	35·2
8·7	58	44·6	42·8
9·5	100	45·0	47·4
10·4	89	49·4	54·6
11·5	91	55·4	64·7
12·5	93	55·7	72·3
13·6	109	57·9	76·8
14·5	114	66·2	80·5
15·5	94	65·6	78·2
16·5	77	66·9	81·3
17·5	56	65·5	84·1
18·4	25	67·2	77·5
19·4	12	70·0	85·3

TABLE 30.

(From Ebbinghaus: *Ueber eine neue Methode zur Prüfung geistiger Fähigkeiten in ihrer Anwendung bei Schulkindern*, Zeitschrift für Psychologie und Physiologie der Sinnesorgane. Digits were dictated and average number of errors per pupil shown.)

Average Age.	8 Digits.	9 Digits.	10 Digits.	6 to 10 Digits.
10·7	3·1	5·1	7·4	17·8
12·2	2·9	4·7	7·9	17·5
13·2	1·5	2·6	4·2	9·1
14·4	1·6	3·0	4·9	10·5
15·5	1·0	2·1	3·7	7·6
17·1	0·8	1·4	3·9	6·5
18·0	0·9	1·4	3·4	6·1

TABLE 31.

(Shaw: *A test of memory in school-children*; Ped. Sem., IV., pp. 61-78. A passage containing 324 words and involving 152 distinct ideas was read. The percentages of terms remembered are given. Sex differences are shown.)

Grade.	Third.	Fifth.	Seventh.	Ninth.	2nd High School.	4th High School.	University.
Boys, -	17	30	37	42	43	38	39·5
Girls, -	18	32	43	44	47	47	

TABLE 32.

(Kirkpatrick: *An experimental study of Memory*; Psy. Rev., I., pp. 602-609. Unrelated words were used. The number of words remembered is given and sex differences are shown.)

WORDS REMEMBERED AT THE TIME.

	Boys.	Girls.
Primary School Students, - - -	5·16	6·06
Grammar ,, - - -	6·74	7·13
High ,, - - -	7·40	7·69
College Students, - - - -	7·89	7·86

WORDS REMEMBERED AFTER THREE DAYS.

	Boys.	Girls.
Grammar School Students, - - -	3·19	3·62
High ,, - - -	3·06	3·47
College Students, - - - -	3·15	3·48

TABLE 33.

(Lobsien: *Experimentelle Untersuchungen ueber die Gedächtniss-entwickelung bei Schulkindern*; Zeit. f. Psychol. und Physiol. der Sinnesorgane, XXVII., 1901, pp. 34-76. Various kinds of material were used and percentages correctly remembered are tabulated to show sex differences.)

Kind of Series.	Boys.	Girls.
Real objects, - - - - -	82·2	91·4
Auditory numbers, - - - -	64·8	71·8
Sounds, - - - - - -	59·6	62·2
Tactual terms, - - - - -	64·2	71·0
Visual terms, - - - - -	60·6	67·2
Auditory terms, - - - - -	59·4	60·2
Emotional terms, - - - -	31·2	59·4
Foreign terms, - - - - -	24·0	23·8

TABLE 34.

(Norsworthy: *Psychology of Mentally Deficient Children*; 1906, pp. 111. Related (but not in sentences) and unrelated words were used. Sex differences are shown.)

Age.	Related words, 288 cases.				Unrelated words, 270 cases.			
	Boys.		Girls.		Boys.		Girls.	
	Median.	P.E.	Median.	P.E.	Median.	P.E.	Median.	P.E.
8	13·0	1·0	13·0	1·6	11·1	1·6	11·5	1·3
9	14·0	2·0	14·0	1·7	12·2	1·7	12·4	1·4
10	15·0	1·7	15·3	1·9	12·2	1·7	14·4	1·4
11	15·0	1·7	16·5	1·7	12·5	1·8	14·3	1·4
12	16·4	1·8	16·0	1·6	12·8	1·8	14·0	1·5
13	16·5	1·8	17·0	1·5	13·5	2·1	13·5	1·5
14	16·9	1·3	17·5	1·5	13·7	2·2	14·0	1·5
15	16·0	1·3	17·5	1·5	13·7	2·2	14·0	1·5
16	17·0	1·3	17·8	1·5	14·0	2·2	14·5	1·5
Adults	16·5	1·5	17·0	1·9	12·8	1·2	13·0	1·4

These tables seem to show that there is a general development of memory power from the age of eight to fourteen. From fourteen onwards some investigators find that no progress is made while others find only a slight improvement. It is probable that memory power remains fairly stationary from adolescence to the age of fifty and then suffers a gradual decline. Girls are superior to boys in "brute memory," but it is doubtful if the superiority persists throughout life. Visual memory develops more rapidly than auditory memory. Memory for emotions is extremely feeble before adolescence. "With boys, the memory for objects is first developed, then words of visual content, words of auditory content, sounds, terms denoting tactual and motor experiences, numbers, abstract conceptions, and, lastly, emotional terms; with girls, the order is words of visual content, objects, sounds, numbers, abstract conceptions, words of auditory content, terms denoting tactual and motor experiences, and emotional terms."[1] It should be remembered, however, that many factors are involved in memory. The effect of practice, the acquirement of powers of concentration of attention, the acquisition of more material wherewith to form associations, and the widening of experience in general, are all instrumental in improving memory.

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[1] Rusk: *Experimental Education*; p. 82.

The Curve of Forgetting. The curve of forgetting can be plotted in two ways: (1) according to percentages of the material retained after given intervals of time, or (2) according to the percentages of the original time which is saved in re-learning. The shape of the curve is the obverse of that of learning. If the material is only just learned (that is, if no further repetitions are made after a perfect recital) about $\frac{1}{4}$ is lost in an hour and $\frac{1}{2}$ in one-third of a day, while about $\frac{1}{4}$ is retained for thirty days. The following table from Ebbinghaus [1] illustrates the point:

TABLE 35.

Interval since the original learning.	Per cent. of retention in nonsense syllables.	Per cent. of retention in poetry.
5 minutes, - -	98	100
20 ,, -	89	96
1 hour, - -	71	78
8 hours, - -	47	58
24 ,, - -	68	79
2 days, - -	61	67
6 ,, - -	49	42
14 ,, - -	41	30
30 ,, - -	20	24
120 ,, - -	3	?

A graphical representation of Table 35 is given below.

Economy in Memorising. This problem is that of economical learning. What is the best unit to use in committing a certain amount of material to memory? The first investigation of the question was undertaken by Steffens.[2] She used Byron's *Childe Harold* and found that the use of a stanza as a unit was better than any smaller one. Her results have been confirmed by Ephrussi and by Ebert and Meumann, and it is now well established

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[1] *Ueber das Gedächtniss*; quoted by Ladd and Woodworth, p. 576.

[2] Steffens: *Experimentelle Beiträge zur Lehre vom ökonomischen Lernen*: Zeitschrift für Psychol. und Physiol. der Sinnesorgane, XXII., 1900, p. 321 ff.

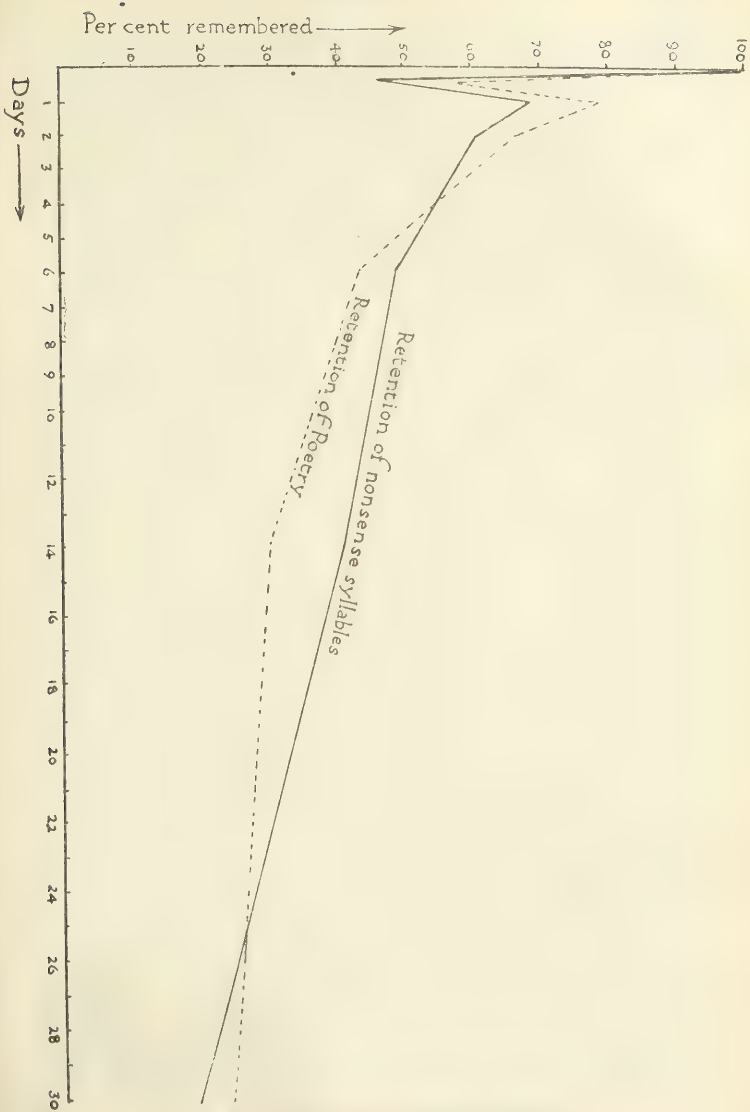

FIG. 28. The curve of forgetting (Ebbinghaus).

that the method of learning by wholes is superior to the common method of learning by parts (piecemeal learning). Pyle and Snyder tried to discover the length of a passage which could be treated as a whole.[1] They used Longfellow's translation of Dante's *Divine Comedy*. The method employed was "to read the poetry over at an even natural rate. As soon as the learner thought that he could repeat some from the beginning, he would do so, and when he came to a halt, would read on through to the end of the unit. It was found impossible, on account of the fatigue, to commit to memory by any method, at one sitting, a unit that could not be learned in 40 or 50 minutes." Large units (60, 120 and 240 lines) were spread over two or more days. The part method was also employed. They found that, without any exception, the method of the whole was more economical than that of parts. The saving of time was about 20 per cent. The extra time in learning by parts is absorbed by the putting together of the parts learned in a proper sequence, and the re-learning of earlier parts which have been forgotten while the later ones are attempted. They conclude that "the most economical procedure will be to read the selection through from beginning to end until it is learned. If the selection is too long to be learned at one sitting of about 45 minutes, it will be most economical to read clear through each time, and to devote 30 or 40 minutes at a sitting, the exact amount of time depending upon the condition of the learner. In the learning of longer selections, the most economical procedure might be to divide the matter up into large units that in themselves made thought-wholes, to commit these to memory separately, and then to commit to memory some device to hold together the separate parts."

What is the best distribution of the repetitions? Is it better to make all the repetitions on one day or to spread them over a number of days? Jost found that it was better to have 2 repetitions on each of 12 days, than 4 repetitions on each of 6, or 8 repetitions on each of 3 days.[2] The longer the time taken, the greater seems to be the chance of the knowledge "soaking in." This does not contradict the principle of concentration as a help in memorising; each repetition must be made under concentrated attention.

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[1] *The most economical unit for committing to memory*; Jour. of Educ. Psychol., VI., 3, March, 1911.

[2] Jost: *Die Assoziationsfestigkeit in ihrer Abhängigkeit v. d. Verteilung d. Wiederholungen*; Zeit. f. Psychol. d. S., XIV., 1897, p. 452.

Other data connected with Memory. With the onset of fatigue the power to memorise vanishes. So close is the connection between the two that Winch, after a series of experiments on immediate memory in children, proposes it as a reliable test of fatigue.[1]

Distractions of all kinds, but more especially auditory interruptions, interfere with memorisation. With a little practice the subject habituates himself to the distraction; a ticking clock soon ceases to be a disturbing factor in one's study.

The value of testimony is dependent upon the accuracy of one's memory. Since memory in young children is weak and apt to be tainted with imagination, too much stress cannot be placed upon their evidence.

Memory power, according to Winch, is favourable to the doctrine of formal discipline. He found[2] that "improvement, gained by practice in memorising one subject of instruction, is transferred to memory work in other subjects whose nature is certainly diverse from that in which the improvement was gained." This is suggested as true so far as children of these ages and attainments are concerned. But Winch's materials were not quite so diverse as he supposed. Memorisation of poetry is not so very different from memorisation of prose passages in history and geography.

Thorndike has shown that paired associates (*e.g.* the English meanings of German words) do not give a curve of forgetting as was obtained by Ebbinghaus, although he found that it was the quick learners who were the good retainers. Thirty hours of practice plus eight hours of testing gave a command over 1200 of these paired associates. At the end of three days 1030 were still known while 620 were remembered at the end of 42 days. The curve in this case is much less steep.[3]

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[1] Winch: *Mental fatigue in day school children as measured by immediate memory*; Jour. of Educ. Psychol., III., 1 and 2, 1912.

[2] Winch: *Transfer of improvement in memory in School Children*; Brit. Jour. of Psychol., Jan., 1908.

[3] Thorndike: *Memory for paired associates*; Psy. Rev., XV., pp. 122-128.

Memory in mental defectives is, as we should expect, much weaker than in normal children. Miss Norsworthy found that only 5 per cent. of mental defectives reached a point that was attained by 50 per cent. of normal children.[1]

The intelligence of animals is dependent upon powers of associative memory. Animals such as sharks and certain other fishes which apparently do not possess associative memory can never be taught anything in the proper sense of the term. Certain Spiders, Crustacea, and Cephalopods possess associative memory, but it is in all probability wanting in Coelenterates and in Worms.[2] In mammals associative memory is fairly powerful, hence the higher educability of these creatures.

Conclusion. Since memory does not increase much in power after adolescence has been reached, childhood would seem to be the time for committing to memory the things which are really worth while. Children ought to be taught to learn things in the most economical manner (see above). The memories of school children are much more efficient than teachers usually suppose. It is probable that nine children out of ten between the ages of 9 and 15 could learn 3000 lines of poetry or prose each year without undue strain. And one-eighth to one-quarter of all the materials learned would be permanent possessions for life.

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[1] *Psychology of mentally deficient children.*

[2] Loeb: *Comparative physiology of the brain*; p. 227

of Experimental Psychology; Chaps. XII. and XIII. Pillsbury: *The Effects of Training on Memory*; Educ. Rev., June, 1908. Steffens: *Experimentelle Beiträge zur Lehre vom ökonomischen Lernen*; Zeit. f. Psy. u. Physiol. d. Sinnesorgane, XXII., 321, 1900. Thorndike: *Elements of Psychology*; Chap. XVI. Thorndike: *Memory for Paired Associates*; Psy. Rev., Vol. XV., pp. 122-128. Thorndike: *Notes on Child Study*; Chap. II. Watt: *Economy and Training of Memory.* Welton: *Educational Psychology*; pp. 368-374. Winch: *Immediate Memory in School Children*; Brit. Jour. Psy., I., 127, and II., 52, 1904 and 1906. Winch: *The Transfer of Improvement in Memory in School Children*; Brit. Jour. Psy., Jan., 1908, pp. 284-293. Whipple: *An Analytic Study of the Memory Image and the Process of Judgment in the Discrimination of Clangs and Tones*; Amer. Jour. Psy., XII., XIII., 1901-2. Whipple: *Manual of Mental and Physical Tests*; Chap. IX.

CHAPTER XII.

SUGGESTION AND IMITATION.

Relation of Terms. Both suggestion and imitation are loosely used in ordinary speech. Suggestion is often used as the equivalent of association, *e.g.* when text-book is said to suggest school. But, in Psychology, it is best restricted to the process by means of which ideas are introduced (usually in an indirect manner) into the normal consciousness of a subject, thereby affecting his beliefs, emotions judgments or acts. In suggestion, ideas are aroused in a manner which prevents, partially at least, contrariant or conflicting ideas from appearing. And as ideas tend to work themselves out in some form of movement, emotion or belief, such an arousal by suggestion will permanently modify the mental make-up of the individual concerned. Suggestion therefore works in exactly the opposite way to persuasion, where conflicting ideas are purposely aroused and arguments produced in favour of one method of action rather than another. "Suggestion is the narrowing of the association-activity to definite contents of consciousness, solely through the employment of memory and imagination in such a way that the influence of combinations of contrariant ideas is weakened or removed, as a result of which the intensity of the suggested contents of consciousness rises above the normal" (Dr. von Schrenk-Nötzing). Keatinge [1] rightly points out that the narrowing of the association activity to definite contents of consciousness is common to all states of the waking mind and should not be used to describe suggestion.

Imitation, strictly speaking, deals with movements, though its meaning can be extended to include feelings, thoughts or ideas. The influence of personal example is necessary to imitation. We can only imitate behaviour which we have previously perceived. "If a *hungry* child begins eating when he sees some one else eating, the act is not properly imitative, for the child knows what eating is, how to eat, and has a tendency to eat, while the sight of some one else eating does nothing but suggest the idea, which would probably be aroused just as effectually by the sight of food or even by the utterance of the word 'dinner' or the sound of a dinner bell. If, however, a child tries to eat *like* some one else, the mode of eating is imitative because the idea of *how* to act is gotten from the observation of the act. If a child eats when *not hungry*, or eats something he does not like because he sees another eating, the act is imitative, because the impulse to perform it results from observing its performance."[1]

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[1] Keatinge: *Suggestion in Education*; p. 12.

Imitation and suggestion, while closely related, are not strict correlatives. It is possible, apparently, to have suggestion without direct imitation as its consequent; imitation, however, must be preceded by direct or indirect suggestion. In general, we may say that suggestion is the method of arousing an act, and imitation is the response to the suggestion.

Hypnotism. During suggestion, as we have seen, there is an inhibition of contrariant ideas. If the inhibition is perfect we get exaggerated suggestion or hypnotism. In hypnotism all antithetical ideas are arrested and commands by word or mouth may be given. "The experimenter says to the subject, 'You cannot advance.' He immediately stands still and makes fruitless efforts to move. He rests glued to the spot. If the experimenter continues, 'Your legs cannot carry you,' he falls as if paralysed. If he says, 'Your right leg is paralysed,' he drags along his right leg as though it were powerless. Even the involuntary muscular system can be affected by suggestion. The effect of a dose of castor oil can be prevented or postponed, and pure water can be made to act as an emetic. Organic changes also, such as blisters, can be produced."[2]

In the category of hypnotism the phenomena of Oriental magic must be placed. Dr. Hensoldt[3] tells us that he saw in the open air and in broad daylight the celebrated rope trick no fewer than four times. "A Yogi after preaching a most impressive sermon, took a rope about fifteen feet long and perhaps an inch thick. One end of the rope he held in his left hand, while with the right he threw the other end up in the air. The rope instead of coming down again remained suspended, even after the Yogi had removed his other hand, and it seemed to have become as rigid as a pillar. Then the Yogi seized it with both hands, and to my utter amazement, *climbed up* this rope suspended all the time, in defiance of gravity, with the lower end at least five feet from the ground. And in proportion as he climbed up it seemed as if the rope was lengthening out indefinitely above him and disappearing beneath him, for he kept on climbing until he was fairly out of sight, and the last I could distinguish was his white turban and a piece of this never-ending rope. Then my eyes could endure the glare of the sky no longer, and when I looked again he was gone."

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[1] Kirkpatrick: *Fundamentals of Child Study*; p. 129.

[2] Keatinge: *op. cit.*, p. 4.

[3] Hensoldt: *Hindu Civilisation during British Rule*; II., 152.

The difference between hypnotism and suggestion during the waking state is really one of degree only. In suggestion there are some inhibitory ideas present but these are not so strong or numerous enough to displace the suggested idea or else it would have no force. In suggestion the influence generally comes through a person's conduct and seldom by word of mouth. The suggestion to steal will not be realised in an imitative act if the counter-suggestions towards honesty are sufficiently strong.

The Process of Suggestion. The suggested idea, according to Keatinge (Chap. V.), arises under certain definite conditions of its own. These are: (1) It must be introduced by a person who is trusted, loved or feared; or under circumstances that inspire these sentiments. The source of suggestion, therefore, is prestige. And it must not be forgotten that children love evident power. A teacher who is an athlete, a good disciplinarian, or a good craftsman will be far more likely to influence his scholars than one who lacks these qualities. The heroes of boyhood are soldiers, sailors, pirates, and the like—all men of action and possessing evident power. Somewhat later in life the power of money and social status is realised. (2) It must be introduced so that reaction is not set up. Reaction can be set up in two ways: (*a*) The idea may be wholly incompatible with the mental content, the sentiment and aims of the subject. (*b*) The idea, though not very antagonistic or possibly neutral, may be introduced in too great a quantity or too persistently and so defeat its ends, through the arousal of counter-suggestions.

Reaction may be overcome by a dominating personality possessing self-control and reserve, inscrutability, masterfulness, sound knowledge and a firm belief in his own point of view. It may be prevented by subtlety in the introduction of the suggested idea. In this case the subject often deludes himself by thinking the idea is his own and is thereby correspondingly elated.

Suggestibility varies according to:

Species. Gregarious animals show more marked suggestibility than solitary ones. Herds of wild cattle, horses, and zebras, owe their continued existence to the rapid response of the members composing the herds to the danger signals of scouts on the outskirts. They "catch" the emotion of fear easily. And the imitativeness of sheep is proverbial.

Race. Savage races living in their native simplicity are as open to suggestion as the most *blasé* of town dwellers. Malays, American Indians, and Chinamen exhibit extreme forms of nervous instability. Of Occidental peoples the Slavs and the Celts are more excitable, *i.e.* more open to suggestion, than the Teutons. Oratory therefore will be a more potent factor in France, Russia and Ireland than in England and Germany.

Sex. Women are probably more open to suggestion than are men yet the results of laboratory tests of illusions are inconsistent. Gilbert, testing children by the size-weight illusion (out of twenty blocks of similar size but of different weights, 5 to 100 grams, the pupil is required to pick out one which is apparently of equal weight to one of two standard blocks—large and small—but equal in weight (55 grams). The large block feels the lighter), obtained the results shown by table 36.[1]

Dresslar concluded that boys are more suggestible than girls and Wolfe considered that women are about twice as suggestible as men.

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[1] Gilbert: *Researches on the mental and physical development of school children*: Studies from Yale Psychological Laboratory, II., 1894, pp. 40-100.

TABLE 36.

Age,		6	7	8	9	10	11	12	13	14	15	16	17
No. of subjects	Boys,	45	50	46	47	49	43	54	45	47	49	47	43
	Girls,	47	45	46	47	42	48	49	58	53	51	39	41
Force of suggestion in grams (medium values),	Boys,	43·5	43·5	45·0	50·0	40·0	38·5	38·0	37·0	31·0	33·0	32·0	25·0
	Girls,	42·0	43·5	49·5	49·5	44·0	40·0	41·0	38·0	33·5	38·0	38·5	31·0

Anthropological evidence is distinctly in favour of the greater suggestibility of women. Ellis [1] shows that women are more hypnotisable than men. Of 360 persons successfully treated by hypnotic therapeutics 265 were women and only 50 were men. There were far more witches than wizards in the middle ages, and women are more frequently converted at revival meetings than are men. Men as a whole are less religious than women and find less satisfaction in suggestive religious exercises. This is especially true in those who profess Christian Science. The greater susceptibility may be due to the social training which women receive: the excitability of temperament certainly seems to disappear as the opportunities for an equal education with men are opened out.

Age. In the preceding chapter we found that the testimony of young children may be untrustworthy because of defective memories; it is untrustworthy under cross-examination because of suggestibility. In young children suggestibility is at its highest although many psychological illusions, *e.g.* the size-weight illusion, the Müller-Lyer illusion, the illusions caused by the Poggendorf, Zöllner and Hering Figures, persist throughout life.

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[1] Ellis: *Man and Woman*; Chap. XII.

Guidi[1] tested children according to their suggestibility to warmth. They were told to push their fingers into a box which was apparently warmed, by a spirit lamp (but not in reality because the light was secretly extinguished by the experimenter). As soon as they felt warmth they were to signal. His results are found below :

TABLE 37.

Age, - - -	6	7	8	9	10	11	12	13	14	15
Per cent. of suggestibility,	50	40·9	51·8	62·5	50	40	33.3	21·4	27·3	33·3

According to this table thirteen is the age of minimum suggestibility but other results are not in entire agreement with this.

Small[2] carried out a series of experiments to see how far illusions of smell could be produced in healthy children and by simple means in the class-room. Rows of labelled perfume bottles were placed in full view of the children. They were told that the experimenter was going to make a spray of perfume in the room and that if any one felt sure that he could smell perfume after the spraying, he was to raise a hand at once. A generous spray of water was then made in various parts of the room. The young children were counted by the experimenter and the older ones were asked to write the name of the perfume on paper. Table 38 shows the results of 540 cases. Strong, faint, etc., refer to those who smelled it strongly or faintly.

Small also carried out other tests of suggestion. He had a toy camel with a rope round its neck in such a way that when he turned a windlass, it appeared that the camel moved, although in reality there was no movement. Out of 391 pupils tested, 291 asserted that they saw the camel

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[1] Guidi: *Recherches expérimentales sur la suggestibilité*; Archiv de Psychologie; VIII., 1908, pp. 49-54.

[2] Small: *The suggestibility of children*; Pedagogical Seminary Vol. IV., pp. 176-220.

TABLE 38.

Grade.	Those who smelled perfume.						Those who did not.	
	No. strong.	% strong.	No. faint.	% faint.	No. not sure.	% not sure.	No. no perfume.	% no perfume.
I.	93	98	..	..	..	..	2	2
II.	62	95	..	..	..	..	3	5
III.	54	83	..	..	..	..	11	18
IV.	55	63	11	13	..	..	19	23
V.	20	50	8	20	..	..	12	30
VI.	19	27	7	9	10	14	35	50
VII.	4	13	..	..	..	..	27	87
VIII.	..	..	..	..	23	67	11	33
High	..	..	25	47	..	..	28	53
Total,	308		51		33		148	% with illusion = 73%.
	392							

move. The percentages of suggestion in the first four grades were 96, 81, 80 and 70.

Binet,[1] among other tests for suggestion, reports the following: A line 50 mm. long was shown by the experimenter to each member of a class and the pupil was asked to draw a line of equal length. In the reproductions there was a marked tendency to draw the line too short. They were then told that they would be shown a longer line which they were to reproduce in like manner. The line which they were shown, however, was actually shorter, measuring only 40 mm. Only 9 out of 86 children resisted the suggestion. As in other cases the younger children were found to be markedly more suggestible than others.

But suggestibility persists throughout life. How else can we explain the action of mobs, the influence of custom, fashions in dress, standards in morality, in oratory and in manners? "You can talk a mob into anything," says Ruskin, "It thinks by infection." And how easy it is to collect a crowd! If one stands and gazes into a shop, seeks for something on the pavement, or gazes intently upwards at a tall building, how quickly one is surrounded by others doing exactly the same thing!

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[1] Binet: *La suggestibilité*; 1900.

The suggestibility of adults is well illustrated by the following: "A professor of chemistry announced to his auditors: The bottle which you see before me contains a chemical with a strong and peculiar odour. I wish to see how rapidly the odour will be diffused through the air and will therefore ask each of you to raise the hand as soon as the odour is perceived." With face averted he then poured the liquid over some cotton and started a stop-watch. In fifteen seconds most of those in the front row had given the sign, and by the end of a minute three-fourths of the audience claimed to perceive the smell. Yet the bottle contained nothing but distilled water, and the professor had been measuring the power of suggestion and not the diffusibility of an odour!"[1]

Literature is full of instances of suggestion. Iago did not tell Othello that Desdemona was in love with Cassio; his subtlety consisted in putting suspicion into Othello's mind without drawing attention upon himself. And how carefully Mark Antony insisted upon the honourable character of the men who slew Caesar! The "School for Scandal" is a classic witness to the power of suggestion put to its basest uses. The innuendo is ever more damning than the accusation direct, so far as adults are concerned.

Fatigue. Fatigue heightens suggestibility. Fasting causes fatigue, hence throughout the ages the seer of visions has employed this device to aid his day-dreaming. Modern life, with its hurry and bustle, tends towards a permanent fatigue, hence the increasing numbers who suffer from hysteria and other nervous diseases.

Practice. Practice tends to dispel suggestibility. Many illusions persist even after much practice (*supra*). But the influence of sermons and moral lessons seems to decrease in proportion to the number heard.

Suggestion in the School-room. Memory, habit and other phenomena connected with mind which we have discussed are individualistic; suggestion is eminently a social phenomenon. No one is neutral; we have either a good or a bad influence upon others. In the schoolroom the greater personality is generally the teacher; sometimes, however, a pupil of the "Speug" variety (*Young*

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[1] *Psychological Review*; VI., 407; quoted by Ross: *Social Psychology*; p. 12.

Barbarians) makes his appearance and woe be to the school if his influence is not for good.

The teacher gains power (*supra*) by: (1) Reserve and inscrutability. In colloquial language, "he must always have something up his sleeve." He must not make too free with the scholars and yet, on the other hand, must not be too "stand-offish." He can take an active interest in the children's welfare without reducing himself to their level. (2) Sound knowledge. The idea that knowing "how" to teach is sufficient, without an adequate knowledge of "what" to teach, is based on a false pedagogy. Scholars love to think that the teacher speaks with the authority of knowledge behind him. If this belief is dispelled his influence wanes immediately. The careful preparation of lessons receives psychological sanction on this ground. (3) Firm belief in his point of view. Sincerity carries great weight. A sincere man, even if he is known to be wrong, is patiently given consideration. But the man who talks "with his tongue in his cheek," who can argue with equal facility on either side in a controversy, wields little power. And school children discover sincerity and insincerity with wonderful facility. (4) Skill in use of indirect suggestion. Suggestion owes its power to the inhibition of critical ideas. It is especially powerful in the realm of moral ideas. A deeply reverent teacher who never "preaches" to the boys is far more likely to be of influence than a mere repeater of moral precepts. The comparative failure of the moral lessons of the "Moral Education League" is due to the bringing into the focus of consciousness that which should have remained on the margin. The object is defeated as soon as it becomes focal unless persuasion and reasoning are brought into play. The principle of contrariance sets in. "Example is better than precept." To be habitually polite, punctual and kind is far better than giving lessons upon these topics.

For some reason, unexplained as yet, the humanities, and more especially the classics, have been considered more fruitful in moral suggestion than the scientific or vocational studies. The suggestiveness of a subject is not inherent in the subject itself, but lies in the method of its presentation. A carefully performed experiment, or a bit of craftsmanship honestly done, is educationally as powerful as a hasty or grudging translation of Caesar.

The Limits of Suggestion. Although our accent, manners, usages of language, dress, morals, political and religious beliefs, are largely a product of the suggestion of our social environment, yet there are limits to its power. Suggestion causes us to be dependent without knowing it—to think and feel like some dominant personality with whom we come in contact. But man is a rational being and if reasoned argument can be used instead of suggestion, it should certainly find a place. If a child can appreciate a motive, reasons and not suggestions should be employed. The child must be taught to depend upon himself. And in case of grave misdemeanours in school the indirect treatment by suggestion is futile ; punishment is then legitimate and necessary.

IMITATION.

In imitation there must be learning from others. The imitative process, therefore, is social in character so far as the observer is concerned. But this does not necessarily mean that the child looks upon it in this particular way. There is plenty of evidence to the contrary. The imitative act is intensely individualistic so far as the child is concerned. He imitates because he wishes to enlarge his experience in that particular manner. This is the ulterior motive in imitation (cf. Stout). In its higher forms it may be constructive in character. And the satisfaction which results from the performance is the motive for its continuation. Imitation therefore persists so long as satisfaction due to the enlargement of experience is a resultant. Children do not try to fly because no satisfactory results accrue ; but they play horses, motor-cars and trains because an enlargement of experience, which is satisfactory to them, however unsatisfactory it may appear to us, is the consequence.

Imitation is the basis of social heredity. In animals it is the only method of carrying on, as it were, the social traditions of the species. Imitation is therefore instinctive ; it has its physical basis in the inherited structure of the body. In its higher forms, other elements are added : voluntary attention and complex ideas become involved in the imitative act. Spontaneous imitation is the highest form found in animals : man alone seems to be able to imitate deliberately. Spontaneous imitation, which, as we have seen, is closely connected with suggestion, is a potent factor throughout life. Not to imitate may be more difficult than "flowing with the stream." We acquire local variations of accent, we read the same books, play the same games, follow the same fashion, and visit the same health resorts as our neighbours.

Forms of Imitation. Kirkpatrick[1] recognises five types of imitation—Reflex imitation, spontaneous imitation, dramatic imitation, voluntary imitation, and idealistic imitation. It must be remembered, however, that the lines of demarcation are quite artificial, that one fades into the other, and that there is much overlapping in actual practice.

Reflex imitation uses physiological dispositions and its stimulus is largely sensory. The crying and laughing of the first year of life are solely of this type. The emotional moods of later life, which are so "catching," are mainly caused by suggestion and reflex imitation.

Spontaneous imitation is a somewhat higher form. "The stimulus is usually a perception of some kind. Everything, from the crowing of chickens to the whistle of a locomotive, from the wriggling of a snake to the preaching of a sermon, is imitated" (p. 131). This form of imitation is dominant between the ages of one and five.

Dramatic or constructive imitation is aroused by the images of previous perceptions. The imitation in this case, unlike the spontaneous variety, is not literal; imagination warps and twists the actions into new and unheard of shapes. The element of make-believe is ever present. Dramatic imitation begins in the third or fourth year and is a potent factor during the next four or five. It coincides with the period when fairy stories make their strongest appeal.

In voluntary imitation the action is invariably performed for some remote end. This necessitates the power to picture the end-results of actions. Memory images, therefore, must function before voluntary imitation can be accomplished. The skills of the school—reading, writing and control of language in general—are largely dependent upon the child's power of voluntary imitation. Such imitation begins about the time the child enters school and attains increasing importance as the standards are passed. For example at about nine years of age the child begins to tire of his poor performances in drawing. The "why" of the rules of drawing should then be insisted upon, for the period of voluntary imitation has now set in.

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[1] Kirkpatrick: *Fundamentals of Child Study*; Chap. VIII.

Idealistic imitation—the deliberative imitation in Stout's classification—is the last to develop. The standard is copied because it is felt to be more correct or desirable. It is guided by concepts and is preceded by critical judgments. Style at cricket and other games is now judged critically and subsequent imitation is based upon some ideal form which is conceived as good and correct. Although found in young children, it is the method *par excellence* for the adolescent. Ideals of right and wrong, good and bad, beautiful and ugly, etc., which govern this type of imitation, are extremely powerful in determining the permanent characters of children.

References. Bagley : *Educative Process* ; Chap. XVI. Binet : *La suggestibilité*. Guidi : *Recherches expérimentales sur la suggestibilité* ; Archiv de Psy., VIII., 49-54, 1908. Haskell : *Imitation in Children* ; Ped. Sem., Vol. III. James : *Principles of Psychology* ; Chap. XXVII. Keatinge : *Suggestion in Education.* King : *The Psychology of Child Development* ; Chap. X. Kirkpatrick : *Fundamentals of Child Study* ; Chap. VIII. Morgan : *Psychology for Teachers* ; Chap. VI. Ross : *Social Psychology* ; Chaps. II. and VIII. Scott : *Personal differences in Suggestibility* ; Psy. Rev., XVII., 147-154, 1910. Scripture : *The Law of Size-weight suggestion* ; Science, N.S., V., 277, 1896. Scripture : *Tests on School Children* ; Educ. Rev., V., 52-61, 1893. Small : *The Suggestibility of Children* ; Ped. Sem., IV., 176-220, 1896. Stout : *Groundwork of Psychology* ; Chap. VIII. Thorndike : *Elements of Psychology* ; Chap. XVIII. Waldo : *Imitation in Children* ; Child Study Mo., II., pp. 75-87. Whipple : *Manual of Mental and Physical Tests* ; Chap. X.

CHAPTER XIII.

ATTENTION AND INTEREST.

Attention and interest are always associated in consciousness: it is impossible to have one without the other. Attention arouses interest, and interest causes attention. Interest is an impulse to know or a tendency to attend; it is also the feeling side of attention. We attend to things which interest us.

ATTENTION.

The activity known as attention may be compared with vision. Whenever we wish to see an object distinctly, we arrange our eye so that the image falls on the yellow-spot—the most sensitive part of the eye. But other portions of the retina are also active and thus we get grouped around the focal image a gradually fading series of peripheral images. Moreover the eye "wanders" and images which were on the margin are brought into the focus, while focal images wander to the margin or disappear altogether. There is, therefore, a continual change both of focus and margin. And so with attention. It is a state of consciousness which presents a focus and a margin. The things in focus are said to be attended to: those in the margin are always grouped about the central focal idea.

The ideas connected with the writing of this chapter are predominantly in focus at the present moment. But the pen, the ink, the paper, the noises of passing vehicles in the street, the warmth of the fire, the room and its contents are more or less vaguely perceived. And as I write out the list, each object for a brief space of time becomes focal; there is a continuous fluctuation which is most complex in character.

We may change our metaphor and compare attention with a peak which rises out of a plain. The summit is the centre of consciousness while the slopes and surrounding plain together make up the margin. The parallel, however, is not a good one for it suggests a static consciousness. The analogy of a wave is a better one. The idea attended to is on a wave which rises above the general level of the water. The wave moves along and causes parts which were formerly depressed to rise in turn above the others.

The focal elements of consciousness, like the focal images of vision, are usually the most important. But the margin cannot be neglected. For example we attend instinctively to moving objects. But these need not be made focal. The ability to see "out of the corner of the eye" is an important factor in survival. In crossing the street we see things on the right and left of us and react without turning our heads. The teacher in the class-room constantly uses marginal images and marginal consciousness. The ability to see Tommy's movements while looking at John is essential to successful teaching. The same ability is made use of by the astronomer, who has learnt by experience that his observations of the meridional passages of the stars are more accurate if he uses the outlying portions of the retina rather than the margin.

Attention is restrictive, selective and unifying. As we attend to an object it becomes clearer in consciousness, while other contiguous objects and ideas fade away.[1]

As a lens concentrates the rays of light and allows an object to be seen with more distinctness, so attention makes the focal constituents clearer and more intense, more enduring and more easily revived. We all know that attention to a bruise increases the pain, and that attention to cold cloths diminishes the headache. As the object attended to becomes clearer, the marginal ones become more indistinct and hazy. A gaudy toy held up to an injured child makes him attend to it and forget his hurt. And severe neuralgia is forgotten in the midst of other excitements. The attention is restricted in all cases.

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[1] It sometimes seems as if the margin actually disappeared: we become so absorbed that we apparently have no subconscious ideas; we become oblivious to everything else. Sometimes, on the other hand, as in day dreaming, we seem to have no focus. The real explanation is that the attention moves so rapidly from one thing to another that none of the ideas lasts long enough to be fully registered.

The selective character of attention emphasises its connection with interest. Of all the objects presented, the attention singles out those that interest. If we show a plant to a farmer, a botanist and an artist, the farmer will look to see if it is a weed, the botanist will notice its parts and classify it, while the artist considers whether it is beautiful or not.

Attention is unifying. The attention of the botanist to the parts of plants leads him to classify widely diverse kinds into the same order. Different plants are recognised as distinct objects, yet his attention, coupled with past experience, enables him to unify them through the recognition of common elements or identities in all. The growth of knowledge consists in unifying facts, events and relations which before were separate. This enables the mind to take in larger and larger wholes in the same act and thus economise its power.

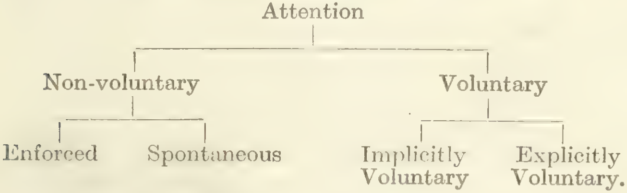
Physiological Accompaniments of Attention. Attention is invariably accompanied by certain characteristic bodily attitudes and physiological changes. These attitudes are assumed to secure for the sense organ appealed to the most favourable conditions for its use. In vision, the head is turned in the direction of the object and the eyes accommodate themselves to the distance of the object and the intensity of the illumination. The breath is controlled and its amplitude decreased so that the movements of the chest will not affect the head. In hearing, the head is turned towards the sound and the eyes are often closed quite unconsciously. Unconscious swayings of the body towards the object attended to and involuntary changes in the circulation of blood are also made. These bodily movements, and especially the rigidity which is so often assumed, cause the well-known feeling of effort during voluntary attention.

Some children, however, get into the habit of assuming the outer attitudes of attention during lessons, while their inner attention may be concerned with other things far removed from the class-room. Dewey calls this divided attention and attributes it to bad teaching. A peculiar look in the eye of a pupil in such a state will rarely escape the observant teacher.

The motor accompaniments of attention are also more pronounced in children than in adults. The wrinkling of the forehead in thinking, the moving of the lips in reading, and the rolling of the tongue in writing, are excellent examples of this superfluous motor discharge. With practice and time these tend to disappear although they remain with some people throughout life.

Types of Attention. We have not a single power of attention but many separate powers. Attention to objects seen is different from attention to sounds heard and so forth. Hence classifications of attention have been made. James [1] classifies in three different ways: (1) Attention to objects of sense (sensorial attention), or attention to ideal or represented objects (intellectual attention); (2) Immediate or Derived. "Immediate, when the topic or stimulus is interesting in itself, without relation to anything else; derived, when it owes its interest to association with some other immediately interesting thing;" and (3) Passive, reflex, non-voluntary, effortless; or active and voluntary. And voluntary attention is always derived. Titchener [2] uses three forms—Passive, Active and Secondary Passive. The secondary passive is the active or voluntary attention which has passed over into the passive form. Thorndike [3] adds a fourth variety to those of James, namely, Native and Acquired. But the classification most widely accepted at the present time is that of Stout.[4] He says:

> "We may broadly distinguish two sorts of Attention, the Voluntary and the Non-Voluntary. In so far as an object excites interest on its own account, attention to it is called non-voluntary. In so far as an object interests us merely as a means to an end, attention to it is voluntary. Non-voluntary attention is either *enforced* or spontaneous. Voluntary attention is either explicitly or implicitly voluntary. Thus we have:



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[1] James: *Psychology*; I., p. 416.

[2] Titchener: *Primer of Psychology*; p. 76.

[3] Thorndike: *Elements of Psychology*; p. 100 ff.

[4] Stout: *Groundwork of Psychology*; p. 50 ff.

"An example will help us to understand these distinctions. A student is working at a Greek play in order to pass an examination. Apart from such an ulterior end he would not be concerning himself with a Greek book at all. It is only or mainly because he intends if possible to pass the examination that he is attending to it at all. Hence his attention is said to be voluntary, as depending on a volition. It would really be better to call it volitional. For there is a sense in which it is involuntary, inasmuch as the student is doing what he does not like. But the term voluntary is imposed on us by current usage.

"As the student is pursuing his irksome task, the sound of a neighbouring piano suddenly assails his ears; some one is playing scales. The noise forcibly challenges his attention, apart from any volition on his part. In other words, he attends non-voluntarily. Further, his attention is enforced, not spontaneous. It is enforced by the abruptness, the intensity, and in general by the obtrusiveness of the sensation.

"This interruption being over, the student again turns to his book. Shortly after, he hears some one speaking. The sound may be less loud than other sounds which he has failed to notice. It may be less loud than other simultaneous sounds. But it is the voice, let us say, of the woman he loves. Again he attends apart from any volition, perhaps even against his will. But attention is not in this case enforced by the obtrusiveness of a sense impression, or any analogous condition. It follows from his natural bias and his preformed interests. In other words, it is spontaneous. The distinction between implicitly and explicitly voluntary attention still remains to be explained. Our student is attending to the Greek play in order to pass an examination. But it may be difficult for him to keep this end in view with sufficient steadiness and vividness. The contents of the book before him have no sort of intrinsic connection with the passing of an examination. Hence in fixing his thoughts on the book he is likely to lose sight of the examination and its significance. So far as this happens his attention will flag, because the derivative interest required to sustain it ceases to operate. The student then again thinks of the examination and pulls himself together, saying, 'This won't do; I *will* pay attention to my book.' Following out this express volition to attend, he turns his mind once more to his task. Here, attention is explicitly voluntary because it follows on an express volition to attend. On the other hand his sense of the importance of the impending examination may have so strong a hold on him that such self-reminders are unnecessary. In that case he may go on attending without framing express volitions to attend. His attention is voluntary because he is not interested in his object except in reference to an ulterior end. But it is implicitly not explicitly so, because there is no express volition to attend."

Welton[1] makes a distinction between attention and absorption. "When we allow the current of our thoughts to be determined by the objects around us we ought not to speak of ourselves as attentive. There is no purpose working in a line of intellectual or practical interest. We make no effort to determine what we shall hear or see next; we accept whatever comes. As an instance let us imagine ourselves present at a cinematograph show. The pictures may be excellent, and may succeed each other without breaks and yet without any suggestive connection. Our interest may be intense; our whole consciousness may be filled by the show; we are so absorbed that we notice nothing else. We are full of enjoyment. But we are not full of thought. It is quite correct to say we are absorbed; it is confusing and misleading to say we are attentive" (p. 237). What Welton describes as absorption is the Native Attention of Thorndike, while what he describes as Attention is the Voluntary Attention of all other psychologists. The new terms only serve to confuse the issues.

The Attention Span. The focus of consciousness is limited in extent, hence the amount that can be attended to at any given moment is restricted. The measure of consciousness when clarified by voluntary attention gives an index of the attention span. The most common method of testing it is to measure the capacity of the subject to perceive visual symbols when these are shown for so short a period as to prevent memorisation. The instrument generally used is the tachistoscope—a short exposure apparatus. This instrument, if properly used, precludes eye-movements and permits only of a glance. The results as summarised by Whipple[2] are as follows: When a series of unrelated objects is exposed (letters, numbers) the average number of impressions that can be grasped in a single exposure lies between four and five. This amount is remarkably constant and does not improve with practice. If the letters are combined to form a nonsense word six to ten letters can be grasped in one exposure. The number of isolated words that can be read is about the same as the number of isolated letters. A word containing 19 or 20 letters can be read at a glance if its meaning is familiar. If words are made into sentences the average reading capacity is from 4 to 6 words. One subject, however, read correctly, "Eine Tochter muss ihrem Vater gehorchen." Simple geometrical figures like circles and squares are more easily apprehended than letters. The amount read seems to increase with age until the adult stage is reached. The attention span correlates with intelligence though not to the extent that is generally supposed. Burt[1] in his experiments found that tests involving reasoning gave much higher correlations. The importance of the attention span in reading is very great, consequently most of the tests have been concerned more or less with this branch of the curriculum. The results are dealt with in the chapter on language (Chap. XIX.).

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[1] Welton: *Psychology of Education*; Chap. VIII.

[2] Whipple: *Manual of Mental and Physical Tests*; p. 232 ff.

The Duration and Shifting of Attention. Closely connected with the attention span are the duration and the shifting of attention. The fluctuations of attention are perhaps best seen by the use of McDougall's Dot Figure.[2]

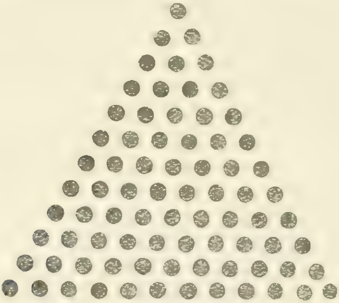

FIG. 29 McDougall's Dot Figure.

The regular arrangement of the dots precludes the dominance of any one particular geometrical formation and consequently, if attention is directed to it for a minute or thereabouts, a regular succession of hexagons, triangles, rhombuses and other figures make their appearance. And it is next to impossible to keep a particular shape, say a hexagon, in focus for more than a few seconds.

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[1] Burt: *Child Study*; IV., p. 93.

[2] *Mind*: 1902, N.S., XI., 316.

Similarly, if a watch is placed at such a distance as to be just heard when attention is directed to it, we find it impossible to hear each successive tick. We hear a few ticks and then miss one or two; the sounds wax and wane. The sounds really remain at the same degree of loudness: the attention ebbs and flows and during close attention the watch-tick sounds its loudest. In this case the rhythmic duration is about three seconds.

Helmholtz found that a uniform grey revolving card became alternately brighter and darker as the gaze was fixed upon it. In listening to a lecture we do not listen uniformly word for word. The attention fluctuates, but the mind is so ordered that it can pick up the threads, as it were, and piece the knowledge together. And if two tunes are played on a piano simultaneously, one with the left hand and another with the right, it is found impossible to follow both tunes at once. When my students were tested, some found first one tune and then the other surging into consciousness; some picked out one tune only; others heard simply a confused medley of sounds; while in no case were both tunes recognised simultaneously as tunes. The shifting of attention is also shown in the phenomenon of "binocular rivalry." If two dissimilar figures or colours are viewed through a stereoscope first one and then the other gains the ascendancy and becomes registered in consciousness.

McDougall[1] explains the shifting of attention as due to the action of drainage and fatigue on branching pathways. A discharge along one pathway causes fatigue and heightens the resistance. The pathway of discharge is then changed to the other unfatigued neurone system until the first has recovered. Rhythm, the short duration of attention, and its continuous ebb and flow are thus explained.

Ladd and Woodworth[2] conceive of the fluctuations as due to the power of varied reaction of each neurone. "The neurone has hitherto been held to have only one form of reaction; but the facts of inhibition, refractory period, etc., seem to indicate that it has at least two opposed modes of reaction, and that these correspond, in a manner, to the opposed reactions of the amoeba. Now the amoeba sends out branches in response to some stimuli, and draws them back in response to others. Some neurologists have believed that protraction and retraction of the dendrites occur, and have based explanations of sleep, etc., on these 'amoeboid movements' of the neurone. The balance of evidence is against these movements, but inner changes of a chemical or electrical nature might have the same results. . . .

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[1] *Physiological Psychology*: p. 130 ff., and *Mind*: 1906, N.S., XV., 329.

[2] *Elements of Physiological Psychology*; 612 ff.

"Suppose, then, that each neurone retains so much as this of the primeval power of varied reaction; suppose that it has two opposite modes of response, positive and negative, corresponding to excitation and inhibition. It may in this case give either response to a stimulus, but more particularly according to its own condition as determined by preceding stimuli and responses. Each positive response is followed by a negative phase, and each negative response by a back swing toward a positive phase. Aside from this substitution of negative response for fatigue, the cerebral action in varied reactions could then be conceived as before, in terms of branching paths, drainage, and summation of stimuli."

Whatever the explanation of the shifting of the attention, certain it is that the focal elements are due to excitations of the cerebral cortex. The message which reaches the summit of the third level succeeds in recording itself and in keeping the others in abeyance. For the cerebral hemispheres can only deal with one message (which, however, may be composed of several parts) at a time. This one is in the focus of consciousness. The other messages, if interpreted at all, seem to be interpreted objectively.

The wandering attention during bodily and mental fatigue can also be explained by the physiological theories. The reduction of reaction-time with attention, as for example in the start of a race to the sound of a pistol, is rather more difficult to explain. We may, however, suppose that expectancy is a means of working up a neurone system until it is just ready to discharge. And in some cases the expectancy is so great that the discharge takes place before the signal. "Calling out" in class is in part due to the phenomena connected with expectant attention.

Attention in School. The power of attention develops with age. As we grow older we increase our powers of voluntary attention and at the same time, through the development of interests, change the directions of our non-voluntary attention. A young child simply *must* attend to novel, clear, intense stimuli, consequently his attention wanders and he is said to be easily distracted. But he is never inattentive ; in fact there is no such thing as inattention during the waking state. His mind must have something with which to occupy itself. His attention, rather, is directed elsewhere. The task of controlling this ever-shifting attention is an important one for the teacher. In some scholars we find a general scatterbrainedness : the attention is similar to that of adults when day-dreaming. This is one of the signs of mental defect. The extreme form of this wandering attention is found in idiots.

Voluntary attention therefore must be encouraged in school. But it involves effort and is fatiguing, and therefore cannot be used for long periods. It, however, brings its own reward. Explicitly voluntary attention, which is obviously the most difficult kind of attention, passes over first into implicitly voluntary attention and finally into the spontaneous non-voluntary variety. With increasing powers of voluntary attention the resistance to distractions and disturbances is increased. Attention to one thing means inattention to others. And if the attention is directed towards thoughts and ideas, there must be inattention to those sense-impressions which previously were so potent. One important function of the teacher therefore is continuously to transfer the attention from lower to higher forms ; from non-voluntary to voluntary, from immediate to derived, and from sensorial to intellectual. The strongest stimulus will always attract, but the strongest need not be an external stimulus : the weak stimulus from within may be so re-inforced as to become the strongest so far as attention is concerned.

INTEREST.

We have seen that, from one point of view, interest represents an impulse to know and so it is closely connected with attention. Looked at in another way, interest is synonymous with the feelings which are aroused when we attend ; hence interest has some elements in it which are characteristic of emotions.

The interest of a thing, however, is not an inherent property of the thing itself, else we should find an interesting object arousing universal interest. But we know that a picture or play, for example, can be absorbingly interesting for one person, while it is hopelessly boring for another. Nor does the interest lie in the subject or we should find that no matter what the presented object was, it would arouse an interest in him. Rather must we think of interest as the emotional values arising out of a peculiar relationship between subjects and objects.

Interests as Ends and Means. Interests are looked upon from two different standpoints by the educator. In the first place they are ends and therefore should be encouraged or discouraged as the case may be ; and in the second place they are storehouses or agencies for furnishing energy and motive power for the acquisition of knowledge.

Kinds of Interests. Interests have been classified as general and special, as native (instinctive) and acquired, and as practical, intellectual and emotional.

By a general interest is meant such a wide thing as interest in the news of the day or in problems of heredity. It is composed of minor interests or special interests. Thus interest in football or in politics are two of the special interests which go to make up the general interest in the news of the day. Interest in Mendelism is a special interest which is part of the general interest in problems of heredity. In exactly the same way, my general interest in the mental and physical life of school-children overshadows my minor special interests in habit, attention and fatigue. Yet the minor interest, for the time being, may become dominant over the all-embracing major interest. As I write on interest and attention, the interest in habit or in exceptional school-children fades into the background, so much so, that what has been written in previous chapters has sunk into the background and is forgotten for the time being, hence repetitions and even slight contradictions may be made unconsciously.

Instinctive interests are present when we attend to a thing without previous teaching ; acquired interests are those which develop through instruction. Thus all of us are naturally interested in the opposite sex, in bright things, in moving things, and in intense stimuli of all kinds. But we are not naturally interested in arithmetic or logic or physics : interest in such things must be acquired. Instinctive interests may, however, be profitably used as the starting point of acquired interests; the interest felt in collecting things, for example, may be used as the starting point for interest in nature study, just about as easily as it is used as the starting point for interest in cigarette cards.

" A practical interest asks—What is the use of it? an intellectual interest—What does it mean? an emotional interest—What is its worth in itself? So with relation to things, the first leads to all forms of invention and useful contrivances; the second to increase of knowledge; the third to the development of all forms of art. In relation to people, the practical interest is concerned with their relations to oneself; the theoretical or intellectual interest with their relations among themselves as seen in laws, institutions, customs; the emotional interest with the intrinsic nature of their moral and social state."[1] Intellectual interests may lead to practical interests and *vice versa,* while emotional interests are ever present. There is much overlapping and distortion, yet the classification is most useful from the standpoint of education.

Interest and Education. The followers of Herbart have allowed interest to become synonymous in meaning with ease or pleasure. Hence the failure of interest as a pedagogical doctrine. Always to obey the dictates of the native interests means the arrest of intellectual progress. The teacher should bear in mind the great satisfaction which comes with the completion of a hard task; and that permanent interests are only developed under the stress of voluntary attention. Children therefore should be given hard tasks, but not so hard as to be beyond their powers from the beginning. Interest in abstract thinking is rare in children, yet most teachers assume that it is omnipresent; whereas practical interests in doing things are omnipresent yet are often stifled through disuse. And practical interests lead on to intellectual interests. Teachers seem fated to develop interests in the wrong things—a painful heritage of classical tradition.

Experimental Study of Interests. The experimental study of interests has been approached from many points of view with the object of determining the changes in children's interests with age. Generally the children have been asked to write answers to questions which would lead them to indicate their preferences in certain matters, *e.g.* "What person would you most like to resemble when you grow up? Why?" "What man or woman mentioned in the Bible do you like best?" "Tell what you would like to do when you grow to be men (and women) and why?" "What character in history do you like best and why?" "What place in the world would you most like to visit and why?"

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[1] Welton: *The Psychology of Education*; p. 199. The chapter in which this classification occurs—" The Development of Interests " —is full of wise things and is well worth reading.

Another method of approaching the subject is to study the collections that children voluntarily make, or the books they take from a lending library.

A third method is to assume that interesting things are longest remembered. Hence the poems and stories of last year which are still remembered are excellent indications of the interest they aroused at the time.

Again, the definitions of common objects which children give, the free drawings they make to illustrate a story, the games they play at different ages, the songs they like best, the things which amuse them can all be used as material for the study of interests.

These methods are not free from objection. The answers the children write or the drawings they make do not necessarily give indications of their interest in the particular subject. The conditions of the test, the locality, and the social status of the subject are important factors. If a child is asked immediately after a lesson on Egypt to state what place he would like to visit, he would probably say Egypt, because Egypt was most prominent in his mind at the time of writing. After a lesson on the Battle of Waterloo there would probably be no places quite so desirable to visit as Belgium, or St. Helena, or Paris. And how difficult it is for us to name our favourite play, book, or author when presented with an album by an importunate child! But in spite of all the objections which have been raised, the results, because of their uniformity, are probably real indications of interests. Most of them, it must be confessed, simply confirm our empirical judgments, and those that run contrary are apt to be looked upon with some degree of scepticism.

The bibliography given in the footnote contains illustrations of the chief methods which have been used in studying the interests of children at varying ages.[1]

To illustrate further the methods employed, outlines of four studies are now given. These are (1) Barnes: *A Study of Children's Interests*; (2) Clark Wissler: *The Interests of Children in Reading Work*; (3) Caroline F. Burk: *The Collecting Instinct*; and (4) An unpublished study, *Ideals of Elementary School Children in a Lancashire Cotton Town*, by Miss Evelyn Gardner. The latter was undertaken as part of the requirements for my Course in Educational Psychology at Manchester University.

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[1] 1. Dawson: *Children's Interest in the Bible*; Ped Sem., VII., pp. 151-178.

2. O'Shea: *Interests in Childhood*; Child Study Monthly, II., pp. 266-278.

3. Barnes: *A Study of Children's Interests*; Studies in Education, I., p. 203.

4. Shaw: *A Comparative Study of Children's Interests*; Child Study Monthly, II., pp. 152-167.

5. Taylor: *Some Practical Aspects of Interests*; Ped. Sem., V., pp. 497-511.

6. Masson: *Children's Interests in Nature and Myth Literature*; Child Study Monthly, pp. 30-43.

7. Brewer: *Instinctive Interest of Children in Bear and Wolf Stories*; Proceedings of Amer. Assoc. for Advancement of Science, 1894, XLII.

8. Davis: *Interest in Causal Idea*; Child Study Monthly, II., p. 226.

9. Ward: *Geographic Interests of Children*; Education, XVIII, p. 235.

10. Barnes: *Interest in History*; Studies in Education, p. 83.

11. Wissler: *Interests of Children in Reading work*; Ped. Sem., V., p. 525-540.

12. Crosswell: *Amusements of Worcester School Children*; Ped. Sem., VI., p. 314.

13. Barnes: *Children's Drawings*; Studies in Education, 2 vols.

14. Taylor: *A preliminary Study of Children's Hopes*; Report of State Superintendent of New York for Year 1896.

15. Thurleer: *What Children want to do when they are Men and Women*; N.E.A., 1896, p. 882.

16. Jegi: *Children's Ambitions*; Trans. of Ill. Soc. for Child Study, III., pp. 131-144.

17. Barnes: *Children's Ideals*; Studies in Education, Vols. I. and II.

18. Willard: *Children's Ambitions*; Studies in Education, I., p. 234.

19. Gates: *Musical Interests of Children*; Journal of Pedagogy, XI., pp. 265-284.

20. Burk: *Children's Collections*; Ped. Sem., VII., pp. 179-207.

1. The aim of Barnes' study was to find what qualities of objects most interest children of different ages. The study was suggested by an experiment conducted by Binet, who, writing in the *Revue Philosophique* for December, 1890, described an experiment he had carried out with his two little girls as follows: He asked the meaning of common words such as horse, clock, bottle and wrote down exactly what they answered. After a month or six weeks he repeated the same list and at the end of 15 such experiments he collated the results. He found (*a*) that their greatest interest in these common objects lay in their *use*, and (*b*) in their *movements*. They hardly ever described an object by telling its colour, form, size, material or structure.

Barnes carried out his experiment with a much larger number of subjects. The teachers of Monterey County, California, were asked to provide the children with writing materials and then to read the following directions: "Write at the top of your sheet the name of your teacher, your own name, and your age. *What is a* knife, bread, doll, water, arm-chair, hat, garden, piece of sugar, thread, horse, table, mamma, potatoes, bottle, flower, snail, mouth, lamp, bird, dog, carriage, pencil, earthworm, shoes, finger, clock, house, wolf, omnibus, ballroom, village, box, handkerchief?"

Returns were obtained from more than 2,000 children: of these only 1,000—from 50 boys and 50 girls of each age from 6 to 15 inclusive—were used upon which to base the generalisations. The answers grouped themselves under the following heads:

1. Use—a clock is to tell the time.
2. Larger term—a clock is a time piece.
3. Action—a clock goes tick-tack.
4. Quality—a clock is pretty.
5. Place—a clock is on a wall.
6. Colour—a clock is yellow.
7. Form—a clock is round.
8. Structure—a clock has a face and wheels.
9. Substance—a clock is made of wood and iron.

In summarising the results each entry was made to show whether the definition was single, two-parted, three or four parted. The resultant 37,136 statements worked out as follows :

TABLE 39.

Years.		6	7	8	9	10	11	12	13	14	15	Total.
Use	Boys,	1246	865	989	997	984	797	819	756	841	747	9041
	Girls,	1238	962	1155	1083	984	780	946	825	724	676	9373
Larger term	Boys,	42	108	120	222	167	282	334	494	496	811	3076
	Girls,	54	111	94	163	250	423	348	573	561	952	3529
Action	Boys,	72	101	85	67	70	88	73	57	71	51	735
	Girls,	18	127	118	74	85	72	75	106	72	47	794
Quality	Boys,	30	55	83	38	33	109	98	87	95	70	698
	Girls,	28	24	37	60	37	119	73	211	96	68	753
Place	Boys,	6	27	36	46	64	86	103	132	78	97	675
	Girls,	2	13	53	43	85	105	132	127	119	71	750
Colour	Boys,	14	37	5	12	9	9	5	7	12	17	127
	Girls,	6	7	11	13	3	8	5	8	17	5	83
Form	Boys,	6	9	8	22	12	39	33	55	62	68	314
	Girls,	2	23	25	12	18	30	28	88	44	74	44
Structure	Boys,	18	20	26	53	48	64	137	150	150	141	807
	Girls,	18	20	35	33	63	78	92	180	167	157	843
Substance	Boys,	26	49	67	137	126	181	227	271	171	251	1506
	Girls,	32	22	72	66	125	184	218	273	233	261	1489
Unclassified,	Boys,	148	151	89	51	167	88	229	166	27	62	1178
	Girls,	134	171	91	82	118	57	123	119	109	20	1924
Total,	-	3140	2902	3199	3274	3448	3599	4098	4685	4145	4646	37136

A gradual change from year to year is noticeable. Young children attend almost exclusively to the *use* of things. Gradually they become interested in classifying them into larger groups and in noticing their qualities, form, and structure. The definitions become broader and contain more statements as the children get older. The seven-year olds gave 2,902 statements, eleven-year olds 3,599, and the fifteen-year olds 4,646. The girls are superior to boys in the essentials of definition—they give more statements and show greater intelligence. The 500 girls gave 18 979 statements while the boys gave 18,136.

Barnes thinks that, if sufficiently extended studies were made, it would be possible to establish criteria for courses of instruction. As it is, the evidence is clear enough to show the wisdom of starting with the uses and activities of objects and gradually leading up to what they can do, what they are made of, and to their structure, form, and colour. And further, we cannot expect elaborate conceptions of things from young children.

2. Clark Wissler in his study *The Interests of Children in the Reading Work of Elementary Schools* used the amount remembered of the previous year's reading as the criterion of interest in the subject matter. Such a study was possible because all the schools of Indiana—the State in which the experiment was carried out—were required to use the State Series of Readers. The Readers contained both poetry and prose—the latter generally in the form of short stories.

The pupils in an ordinary composition lesson and in ignorance of the purpose of the questions were given the following instructions : " (1) Write the subjects of all the lessons that you remember from the Reader you used last year ; (2) Which one did you like best ? What was it that you liked ? (3) If you were taken to a book store and told that you might select just one book for your own, what would you take ? (4) Give your *name, age* and *grade.*"

From 2,100 papers received, 1,950 papers, 1,060 from girls and 890 from boys, were selected. The ages of the children ranged from 8 to 15.

(1) Certain lessons were remembered by the majority of the pupils, others by a few or none. The following summary represents the facts of the case :

	2nd. Reader.	3rd Reader.	4th Reader.
Per cent. of total number of lessons not recalled - - - - -	1	17	33
Per cent. of lessons recalled by 5 per cent. or less - - - -	34	40	11
Per cent. of lessons recalled by an average proportion - - -	55	34	33
Per cent. of lessons recalled by the majority of pupils - - -	10	9	23

Conclusions : "The first lesson of the different Readers is well remembered, also the continued lesson, or long story.

All of the lessons remembered to any great extent, except a few remembered for their oddities, are in terms of experiences the child can realise for himself. The lessons remembered most are especially natural, or life-like. The curves of the sexes are remarkable in agreement, that of the one appearing as a duplicate of the other. The principal difference is in the number of lessons remembered, girls remembering more than boys. The lessons not remembered by any child are too short to excite interest or do not treat of things a child can appreciate. The mere instructive lesson; the moral and its setting; abstract poems concerning duty, happiness, love of nature, etc., make up 5 per cent. or less of the bulk of those remembered."

(2) With respect to preference, poetry was increasingly preferred to prose as the pupils progressed in age. Girls more frequently than boys preferred poetry. The subjects were chosen chiefly because they were true to life, contained moral lessons or were heroic in action.

(3) The children chose no less than 246 different books, but, with perhaps the exception of Longfellow's Poems, none could be said to be popular. Fifty-three per cent. chose fiction, 14·5 per cent. poetry, 7·5 per cent. history, 5·5 per cent. biography, 5·0 per cent. religious works, 2·0 per cent. science, and ·5 per cent. each travel and humour. Boys had a wider range of choice than girls and exhibited greater individuality: they chose actions in which strength and courage were displayed, while the girls chose actions in which affection and kindness strove for the good and the true.

3. Miss Burk attacked the problem of interest by investigating the collections which boys and girls made. From the reports of 607 boys and 607 girls the following facts are indicated.

(1) The impulse to collect is instinctive and therefore practically universal.

(2) It begins at the age of 3, rises rapidly from 6 to 10, and thereafter suffers a gradual decline.

(3) The variety of the collections is remarkable and their nature is determined by environment or imitation.

(4) Certain collections are prominent, showing the force of imitation as an incentive.

(5) In childhood, there is a crude instinct to collect anything; in pre-adolescent years a more purposeful interest

arises in which interest in the things themselves becomes prominent; in adolescence, a genuine interest is exhibited only in aesthetic and literary collections. Imitation degenerates into faddism—sentimental or social.

(6) Gifts form the basis of the collections in childhood, while in later life personal efforts are made to acquire things. Barter or trade is an important factor in adolescence.

(7) The chief motive for the formation of a particular kind of collection is the influence of others, while interest in quantity is second. There is little interest shown in the things themselves or in kind. The interest in kind is chiefly in the number of kinds.

(8) Classification is unusual and does not appear before nine or ten. The basis is colour or size, and seldom kind.

The following table gives some of the prominent collections and the percentages of children making them.

TABLE 40.

Collection.	Per cent.		Collection.	Per cent.	
	Boys.	Girls.		Boys.	Girls.
Cigar tags, - -	64	24	Flowers, - - -	2	10
Stamps, - -	60	39	Ribbons, - - -	1	10
Birds' eggs, - -	47	13	Stones, - - - -	7	6
Marbles, - -	36	22	Pebbles, - - -	2	7
Shells, - - -	18	36	White horses counted,	1	7
Picture cards, -	9	33	Picture buttons, -	6	5
Pictures, - -	9	22	Coins, - - - -	6	4
Buttons, - -	14	23	Pieces of glass, -	3	6
Pieces of cloth, etc.,	1	20	Butterflies, - -	5	3
Paper dolls, - -	1	17	Election cards, -	6	1
Dolls, - - -	—	16	Beads, - - -	1	6
Books, - - -	7	12	Spools, - - -	3	4
Rocks, - - -	11	9	Badges, - - -	4	2
Leaves, - -	7	11	Strings, - - -	1	4
Sea mosses, - -	3	16			

The useless and paltry nature of most of the collections is obvious. It is probable that a most valuable asset in education—the instinct to collect things—is being allowed to run to waste. Proper direction would cause the instinct to satisfy itself upon things worth while and of educative value.

4. Miss Gardner used the *Ideals of School Children* as a basis for the study of interests.

The question paper given below was sent to the children in a Radcliffe school whose ages were between 8 and 12:

1. Name of school.
2. Name of child.
3. Age of child.
4. Occupation of father.
5. What do you want to be when you grow up? Why?
6. What book do you like best? Why?
7. What living person do you like best? Why?
8. What person in history do you like most? Why?
9. Which part of the Bible do you prefer—the Old Testament or the New Testament?
10. Which of the Bible characters (excluding Jesus Christ) do you admire most? Why?
11. What English King would you most like to have met? Why?

The questions are similar to those previously set by Earl Barnes and others in London and America. The study could not be carried on beyond the age of 12 in this particular town because of the prevalence of "Half-time" employment. "As soon as a boy (or girl) reaches the age of 13, he gets his 'attendances' and begins to work. The majority of the Radcliffe Elementary School children leave school on their 13th birthday, while the better classes go to the local grammar schools somewhat earlier. In the school examined, there were only two boys over 12 years of age, and no girls. The same conditions prevail in all schools throughout the district."

The fathers of the children are for the most part engaged in manual labour—mining, carting, weaving—and very often the mothers are mill-hands also, or were before marriage. Of the 117 children studied, 24 were 8 years of age, 28 were nine, 17 were ten, 17 were eleven, and 31 were twelve.

From answers to questions four and five the following table was compiled :

TABLE 41.

Age.	Percentage following relative's occupation.	Percentage choosing because they like it.	Percentage choosing because of wages.
8	62·5	37·5	. .
9	18	82	. .
10	23·5	53	23·5
11	11·7	23·4	64·9
12	. .	19·3	80·9

These results show that money has little or no influence in the choice of occupation by young children ; they choose the occupations of their fathers, sisters or brothers. The age of nine or ten marks a change, and shows the beginning of a critical attitude. The love of outdoor life and of horses is responsible for the 82 per cent. at the age of nine. The love of gain becomes prominent at 11 and 12 and the occupation is chosen because of the wages to be earned while following it. The girls were in every case more imitative than boys.

The books chosen showed the lack of general reading by Lancashire elementary school children. They chose *Oliver Twist*, which they were reading in school, or in a few cases, "penny-dreadfuls" of the type "Redskin and Cowboy."

The questions asked concerning historical and living persons gave rise to the following table :

TABLE 42.

Age.	Historical Characters.		Living Persons.	
	Per cent. remote.	Per cent. near.	Per cent. famous.	Per cent. local.
8	83·3	16·7	70·8	29·2
9	85·2	14·8	50·0	50·0
10	94·1	5·9	58·8	41·2
11	53·0	47·0	58·8	41·2
12	35·5	64·5	86·5	19·3

It is interesting to note that younger children are interested in the more remote historical characters like Alfred the Great, Hereward the Wake, while older children are much more impressed by the importance of individuals recently deceased. With increasing age there is shown an increasing capacity for true judgment. Local personages sink in importance and world-known politicians and scientists like Asquith and Marconi come into prominence. Even kings give way before politicians, for politicians were chosen three times more frequently by children of twelve. Girls chose local magnates more frequently than boys.

The Old Testament was preferred to the New, and the majority of the Biblical characters were selected for their goodness or their bravery. Joseph was prime favourite though he was closely followed by David, and more remotely by Daniel and Samuel. Of New Testament characters, John was the favourite; and he was followed at some distance by Peter, Matthew, Mark, Luke and John the Baptist. One boy admired Judas most "because of his cleverness." As the children grow older they admit kindness, humaneness and honesty as characteristics worthy of idealisation.

The most noticeable feature about the whole of the papers is their lack of originality. Apparently the children are content to accept the judgments of their elders and especially their teachers. A paucity of knowledge which forced the children to write consistently the few names they know would account for the facts. Miss Gardner is pursuing the subject with children in different classes of society and in different towns to elucidate the matter.

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SECTION IV.

DESCRIPTIVE PSYCHOLOGY.

CHAPTER XIV.

PERCEPTION.

Definition of Perception. Consider the following definitions of Perception :[1]

(1) " Perception is the act of interpreting sensations in such a way as to give us a *knowledge* of external objects."

(2) " The consciousness of particular material things present to the sense is called Perception."

(3) " Perception is the apperceptive or synthetic activity of mind whereby the data of sensation take on the forms of representation in space and time."

(4) " Perceptions are mental contents due to the joint activity of our sensation and apperception."

(5) " The perceived thing is not simply the physically present vibrations of atoms and molecules which we call light or sound or what not. It is these vibrations as they are interpreted by the psycho-physical organism which exposes to them a nervous system already affected by past experiences that enable it to get only certain specific kinds of results from the present syntheses."

(6) " Perception is the gateway through which the mass of sensory excitations (save those grown purely habitual) must pass before they can be admitted to set up responses of the volitional kind."

All the definitions emphasise the fact that perception is dependent upon the stimulation of some sense organ. But a pure sensation, as we have seen, is an abstraction—

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[1] Collected by Sinclair and Tracy : *Introductory Educational Psychology* ; p. 70.

a fiction of psychology. Only our first experience of an object can possibly be a sensation. The second experience recalls part of the first one and we get a perception. All subsequent experiences help to elaborate the perception. Thus the perception of a table is a combination of all previous experiences of tables together with the sensations due to the particular table considered. Hence perception involves the retained elements—traces left behind in the nervous system by previous sensory stimulations—as well as sensation. But we must not think that a perception is a mere " mixture " of sensations and ideal elements ; it is a unit—an undivided whole—and when a new sensation is added, it modifies the whole, just as adding a new element to a chemical compound makes the whole different. Further, the sensations do not come before consciousness as separate things but as different aspects of one whole perception. There are objective and subjective elements in every perception and these continually fuse together to form new wholes ; every new objective element added complicates the perception.

Unless the sensory excitation is actually taking place at the time, we do not get perception. If we think of a table we get ideation and not perception of a table. Touch and sight may give us a perception of a table although the part touched or seen is but a small part of the whole object. The sight of the top of a table is sufficient to give us a clear perception of a table with its various qualities—legginess, smoothness, squareness, etc. Our past experience elaborates the part into the whole. But it must not be thought that perception depends solely upon sight and touch. Other sensory stimuli may be the starting points of perceptions. The smell of a rose may recall the rose ; and the mere sound of a street piano may be elaborated into a clear perception of the whole instrument.

The definitions also emphasise the fact that in perception we always perceive something which we term a " thing." In looking at a table we do not get a vague blur of brown colour, a dim idea of smoothness and so forth, but we perceive a thing—the table as a whole, into which smoothness, colour, and many other elements enter. The " thingness " usually presents itself to us by means of a number of impressions on several sense-organs ; and these we combine together according to our practical interest. What portion of matter is termed a thing depends upon the interest of the subject naming it. To most people a cart is a single thing, to a wheelwright one of its wheels is a thing, while to the nailmaker a single nail in the wheel is just a thing.

Thirdly, the definitions show that the perceived object must have attracted the attention. Thousands of sense stimuli clamour every minute for recognition in consciousness but only the one which attracts the attention is perceived. The perceived thing occupies the focus of consciousness and this gives it certain attributes such as clearness and exclusiveness.

Since perception is dependent upon the retention of previous experiences, it follows that perception, in part, depends upon our native and acquired interests. The same object may excite different perceptions in different individuals. To use once more the illustration of the farmer, the botanist and the artist viewing the same plant; they obtain different percepts because their interests have given them different retentions in each case. To most passengers on board ship the sextant is a " brass thing " or at most " an instrument of some kind," but to a navigator it is far more; it is an instrument used for measuring angular distances and is closely associated with latitude and with previous experiences of its practical use.

Similarly Thorndike[1] expresses the same truth when he says, " To the man without musical training the song sung by a chorus is a vague total of sounds, but to the trained musician it is a balanced harmony in which all the different parts are clearly felt. To the five-year-old a page of print is an indefinite smear of black specks on a white ground; to his teacher it is a definite series of letters and words; to the printer it is not only that, but also 10-point type."

The amount of sensory element necessary to arouse perception becomes less and less with time. In fact an intense stimulus startles rather than informs. In reading we at first perceive minute differences between words and letters, but with practice a mere ghostly outline of a word is sufficient to give us the meaning. Consequently adults tend to overlook printer's errors.

Pillsbury[2] tried to determine the amount of change which might be made in a word without change in character of the resultant preception. Letters in a word were varied with respect to their positions and character, and the maltreated word was then shown to the subjects for a brief interval of time. The evidence showed that there was a conflict between the objective and subjective elements of perception. In some cases the subjective element won the day for " the suggestion from the association was stronger than the visual impression in determining the word read." After showing many adverbs ending in *-ly* the combination *fellw* was exhibited and was read *folly*, the subject declaring that he had seen every letter in the word he read. The most confident statements seemed to be made when the letters were not actually on the slide, but were added subjectively. " These facts show that for the individual the centrally excited sensations are just as truly real parts of the word perceived as the peripherally excited."

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[1] *Elements of Psychology*; p. 36.

[2] Pillsbury: *A study in Apperception*; Amer. Jour. Psy., VIII., p. 356 ff.

Percepts and Ideas. A percept stands between a sensation and an idea in the ascending scale of mental life. Sensation passes over into perception and perception develops into ideation. The greater the proportion of the sensory or objective elements in perception, the nearer it approaches sensation. The greater the amount of ideal or subjective elements, the nearer it approaches ideation. But the transitions from sensation to perception and from perception to ideation are gradual and difficult to define. In practice, sensation is limited to descriptions of single qualities of things, while perception describes whole things or groups of qualities which a thing possesses. And if a man has reached a stage of mental development when he can construct the whole of an extinct animal by the mere examination of a small fossilised bone, he is working on the very borderland of ideas.

A percept differs from an idea in the qualities of clearness, passivity, steadiness and " singleness." I look at the paper on which I am writing and it stands out with surprising clearness. The whiteness, the smoothness and other qualities of the paper force themselves upon my attention ; but when I turn away and think about writing-paper the vision fades and becomes dim and abstract. To get a percept, one only needs to be quiescent and passive. The percept comes of itself without any feeling of effort. And it remains fairly steady ; it does not fluctuate like an idea.

Further, it possesses a unity or singleness peculiar to itself. I see the paper as a whole and this is at once satisfying and complete. The idea, on the contrary, is active and restless. One idea follows another in quick succession; an idea is invariably a member of a "train."

But the description of a percept as passive and steady must not be construed to mean that it is fixed and invariable. As a matter of fact a percept tends to start a train of percepts which run until some satisfactory end has been reached. If we get a "train" of ideas we certainly get a "series" of percepts. Moreover, a percept may start a train of ideas and often does. This simply emphasises the fact of the close connection between perception and ideation.

But the idea is by far the better tool of thought. It is, as Stout says, "a *significant* mental image." It is more plastic—less rigid—than a percept. In a percept we are limited to the actual thing from which emanates, as it were, the various sensory stimuli. Not only does a percept fail to combine with other percepts but it actually prevents other percepts from arising. An idea on the other hand combines most freely with other ideas. It may therefore be used for planning in the future, and for making new ideal constructions, or re-arrangements of old knowledge. Paraphrasing Stout,[1] we may say that humans live in a world of ideas, animals in a world of percepts. A monkey could learn to strike with a stick and cut with a stone; it could never combine the two ideas and learn how to make a stone-hammer.

Perception, Illusion and Hallucination. If we get an impression of an external object which does not correspond with the external object we are said to experience an illusion. Thus I may think that a coat hanging on a door of a dimly lighted room is the figure of a man. The experience would constitute an illusion. And the apparent curving of the parallel lines of the figure on page 242 is a permanent illusion of mankind.

If, however, I see a man standing behind the door when nothing is present to cause such an experience, I am said to suffer an hallucination. The object is perceived just as clearly as if it were actually present to sense. Hallucinations are of very infrequent occurrence with normal people; with the insane and those suffering from *delirium tremens* they may be the ordinary waking experiences. A number of well-authenticated cases of hallucination may be obtained from James[1] and from the publications of the Society for Psychical Research. James, in addition, discusses the theories which have been put forward to explain the phenomena.

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[1] *The Groundwork of Psychology*; p. 104.

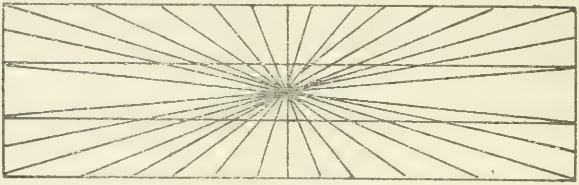

FIG. 30. Hering Figure.

Illusions, on the other hand, are fairly frequent in normal mental life and would occur still oftener if it were not for the fact that we test perceptions obtained through one sense by those obtained through other senses. Illusions of sight and hearing are fairly common, and in some cases are permanent possessions, because of the difficulty of testing such experiences by means of touch, smell or taste.

It was known to Aristotle that an object held between the crossed fingers felt double. Size when estimated by touch invariably seems larger than when estimated by sight. The particle which is *seen* to be a speck of dust *feels* at least the size of a pea if it gets beneath an eye-lid. And the dentist always fills us with dismay when we explore with the tongue the size of the cavity he makes for a filling. But the filling itself, when seen through a mirror, is found to be quite small.

Some of the geometrical illusions of form and size are difficult to explain. Why, for example, should a vertical line appear to be longer than a horizontal line of equal length, and more especially if one stands on the other. This illusion causes a perfect square to seem higher than it is broad.

The explanation usually given is that vertical motion of the eye involves greater effort than horizontal and we judge distance, partly at least, by the effect of motion of the eye-ball.

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[1] *Psychology*; II., pp. 114-131.

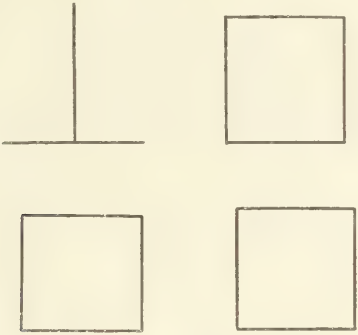

FIG. 31. Vertical Distance Illusion.

That some of our habitual perceptions of size are inaccurate is seen by such an example as the following :

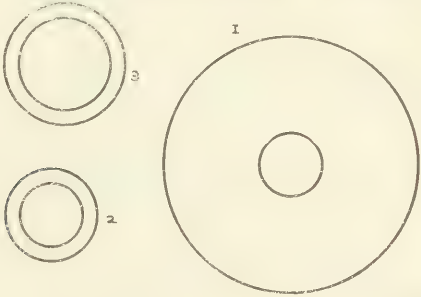

FIG. 32. Ring Illusion: Confluxion and Contrast.

The small circle of 2 appears bigger than the small circle of 1, while the large circle of 2 appears smaller than the small circle of 3. Yet they are equal in each of the two cases. We judge of 1 and 2 as rings of a size intermediate between the circles composing them. The outer circle narrows and the inner circle widens by contrast in each case. But in 1 the circles are so wide apart as to be judged independently.

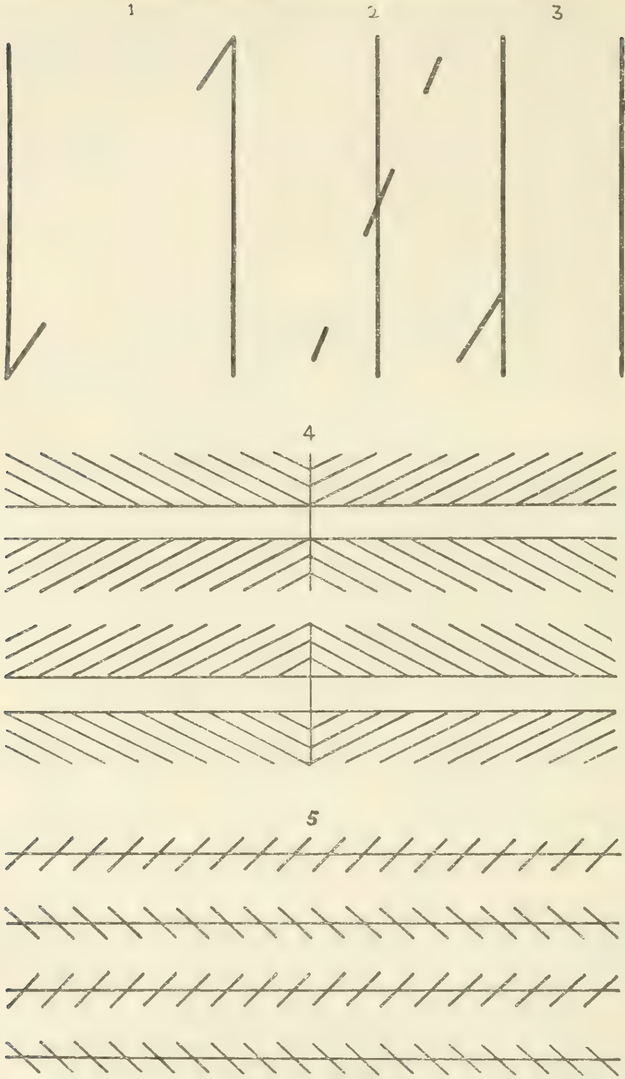

FIG. 33. Angle Illusions:

1. Double Angle Illusion.
3. Poggendorf Figure.
2. Simple Angle Illusion.
4. Hering Figures.
5. Zöllner's Pattern.

The various forms of angle illusions are extremely interesting. The general explanation of angle-illusion is that acute angles are normally judged greater, and obtuse angles smaller, than they really are. The explanation is not wholly satisfactory, for the influence of the relative lengths of the arms of the angle, which is considerable, as can be seen from the preceding figures, has been neglected.

In the case of reversible perspective figures we have one series of sense-stimuli connected with two or three definite perceptual systems.

The nervous impulse does not spread over the whole of the possible perceptual systems thus causing a blur, but takes one alone. Consider Fig. 34. It may be looked upon as a plane geometrical figure, or as a long open passage looked at in perspective, or as a truncated square pyramid standing on its base. As we fix our gaze upon the figure we get a fluctuation of the percept. By adopting the following plan we can see at will the form we want to see. We cover the figure with the hand, picture mentally the particular form we wish to see, and then remove the hand and look at it. The form we conceived is the one perceived. Pre-perception therefore plays an important part in perception.

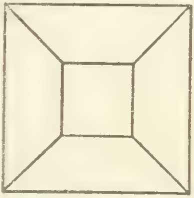

FIG. 34. Reversible Perspective Figure.

In solving puzzle-pictures we seem to need these pre-perceptions. At a first glance we get vague sense-impressions which are not far removed from simple sensations. We then picture the hidden object and hunt around for something which will fit in with our pre-perception. Suddenly the hidden figure is recognised, it jumps into consciousness as it were, and we wonder how we could have been so stupid as not to see it before.

If the pre-perception is vivid and strong, it actually hinders the solution. Thus a knowledge of French and German misleads us in the following "catches" for it makes us strive to translate:

1. Pas d'elle yeux on que nous.
2. Pas de lieu Rhône que nous.
3. Gui n'a beau dit, qui sabot dit, nid a beau dit elle.
4. Von der Vottei mit is.
5. Mein die Uhr onbiss Nüss.

As the familiar English phrases, of which these are merely phonic transcripts, are recognised, we feel a shock similar to that experienced in the case of puzzle-pictures, and the sentences take on a totally different meaning.

And in teaching, the *aim* of a lesson must be clearly understood by the scholars so that pre-perceptions will help to make subsequent information and procedures significant.

Perception of Space and Time. These problems are among the thorniest of descriptive psychology. The controversial aspects are so difficult that only the merest outline of the problem can be given.

With respect to the question of perception of *space*, most psychologists agree with the statement of James[1] "that this element (extensity or voluminousness), discernible in each and every sensation, though more developed in some than others, is the original sensation of space, out of which all the exact knowledge about space that we afterwards come to have is woven by processes of discrimination, association and selection."

The chief organ of space is the eye. By means of the effort of accommodation, the size of the image, the angular movement of the eye-ball in its socket, the dimness of vision due to distance, and the convergence of the two eyes upon a single point we obtain excellent ideas of spatial relationships. But the stimulation of the skin also helps in the perceptions of space. We know, for example, the effect of the application of two points to the skin when an intermediate area of skin is unstimulated. Moving a point along the skin gives a second kind of perception, while the application of a straight edge gives a third. Distance is also perceived by placing bodies between movable parts of the body such as the thumb and fingers. The extent of the movement of the limbs (kinaesthetic sensations from muscle, tendon to joint) gives excellent spatial perceptions. Auditory sense stimuli are very unreliable as indicators of spatial distances, while smell stimuli are even more so. But all percepts from touch, smell, sound, etc., are interpreted in terms of visual perception. The other senses simply confirm or disprove the results obtained by sight. A unity is thus given to the external world of the "not-self."

Accurate spatial perception is of fairly slow development.

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[1] *Psychology*; II., 135.

The baby "cries for the moon"; the adult has great difficulty in guessing the length of 100 yards.

The perception of *time* is generally assumed to be due to the overlapping of mental processes. Those reach their maximum activity and then fade away. The clear ones are in the present, the fainter ones which are but the dying phases of processes lately exhibiting a maximum activity are in past time. The amount of overlapping determines the duration of time, and the overlapping itself, the place of events in time order.

We are only distinctly aware of "now"; the past and the future are vague; our feelings about them are simply "no longer there" and "not yet there."

The "present" is of short duration, not exceeding six seconds in length. Time is largely judged by what happens in it. But empty time in the present is impossible; if external events are absent, it is filled in with breathings, winks, heart-beats and other bodily functions.

Tests of Perception. All mental tests involve perception (and attention). In order to test perception it is only necessary to increase the amount of the perceptual element and reduce to a minimum the other factors involved in the test.

The most usual test for perception is the one known as cancellation. In this test a certain letter or letters are crossed out, either from an amount of special pied type or from the pages of a magazine. The simplest form of test is the Columbia "A" test. This consists of a sheet printed with capital letters to make a pied type as shown below. The subject is told to "mark as many A's as he can and as quickly as possible." The time taken, the number of A's marked and the number omitted are all recorded.

OYKFIUDBHTAGDAACDIXAMRPAGQZTAACVAOWLYX
WABBTHJJANEEFAAMEAACBSVSKALLPHANRNPKAZF
YRQAQEAXJUDFOIMWZSAUCGVAOABMAYDYAAZJDAL
JACINEVBGAOFHARPVEJCTQZAPJLEIQWNAHRBUIAS
SNZMWAAAWHACAXHXQAXTDPUTYGSKGRKVLGKIM
FUOFAAKYFGTMBLYZIJAAVAUAACXDTVDACJSIUFMO
TXWAMQEAKHAOPXZWCAIRBBRZNSOQAQLMDGUSGB
AKNAAPLPAAAHYOAEKLNVFARJAEHNPWIBAYAQRK
UPDSHAAQGGHTAMZAQGMTPNURQNXIJEOWYCREJD
UOLJCCAKSZAUAFERFAWAFZAWXBAAAVHAMBATAD
KVSTVNAPLILAOXYSJUOVYIVPAAPSDNLKRQAAOJLE
GAAQYEMPAZNTIBXGAIMRUSAWZAZWXAMXBDXAJZ
ECNABAHGDVSVFTCLAYKUKCWAFRWHTQYAFAAAOH

In the *a.t.* and *r.e.* tests, prose selections in a foreign language, *e.g.* Spanish or Hungarian, are employed, and the subject is told to "mark all the words containing both *a* and *t* (or *r* and *e*) as quickly as possible" and the records are kept as in the "A" test.[1] Tests employing other combinations of letters have also been used. The counting of dots, the reading of complicated or nonsense prose, and the description of an object which has been shown for a short space of time, have also been used with some measure of success as tests of perception.

The results show that perception becomes quicker and more accurate with age; that women are, as a rule, better than men; that practice improves perception; that fatigue increases errors but not the speed of perception; and that perception and intelligence are not very closely related.

References. Angell: *Psychology*; Chaps. VI., VII. Baldwin: *Mental Development in the Child and the Race.* Calkins: *A First Book in Psychology*; Chaps. II., III., IV., V. Hall: *Aspects of Child Life and Education.* James: *Principles of Psychology*; Chaps. XII., XV. and XIX. Judd: *Psychology*; Chap. V. Myers: *Text-Book of Experimental Psychology*; Chaps. XXII and XXIII. Preyer: *The Senses and the Will*; Eng. trans., pp. 6-22. Rusk: *Introduction to Experimental Education*; Chaps. V. and VI. Seashore: *Elementary Experiments in Psychology*; Chaps. IV., V., VI., VIII. and XIV. Titchener: *A Primer of Psychology*; Chap. VI. Thorndike: *Elements of Psychology*; pp. 35-42. Whipple: *Manual of Mental and Physical Tests*; Chap. VII.

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[1] See Thorndike: *Educational Psychology*, Appendix II.; and Whipple: *Manual of Mental and Physical tests*; p. 254 ff. for detailed descriptions and results of the tests.

CHAPTER XV.

IMAGINATION AND IMAGES.

Meaning of the Terms. Psychology, like Education and Economics, is seriously hampered in its development by the necessity of giving some terms of ordinary speech certain narrow and highly specialised meanings. Medicine suffered a similar inconvenience until it was made bilingual. One speech, popular and non-technical, is now used in describing cases to the layman, while the other, specialised and technical in its phraseology, is reserved for the expert. What meaning, for example, has the following passage for the ordinary layman ? [1]

> " The lower portion of the lamina terminalis is thickened by the anterior commissure, and the upper portion of it is also thickened by a transverse band of fibres known as the olfactory decussation. Immediately above the olfactory decussation is seen a short triangular projection of the ventricle which marks the point at which the neural tube remained longest in connection with the ectoderm. This was probably at the upper border of the neuropore and the little sac is called the recessus neuroporicus. From the recessus neuroporicus back to the neuclei habenulae the roof of the median ventricle is membranous. This is a part of the true brain roof and does not belong to the lamina terminalis. There is no such thing as a pars supraneuroporica of the lamina terminalis."

Although Psychology is gradually developing special technical terms of its own, it is, unfortunately, still compelled to use certain common words like sensation and imagination, and to these restricted and specialised meanings must perforce be given.

But our difficulties with terms are not yet over. The word " imagination " is used technically in two ways. There is a wider and a narrower connotation of the term. In its wider meaning imagination includes *all* imaging and thinking in images. It therefore is equivalent to imagination in its narrower sense *plus* imagery. Imagination in its narrower sense is restricted to those cases where images are recombined to form new wholes. We are said to *imagine* the things we have never actually experienced. Imagery refers to those cases where pictures of specific parts of one's past experience are recalled; we can *image*, *i.e.* form mental images, only of the things we have actually experienced. Thus we can *image* a snow landscape in England, but we can only *imagine* a snow landscape in the South Polar regions.

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[1] Johnston : *The Nervous System of Vertebrates* ; p. 295.

The word "image" has various meanings in Psychology. We speak of *after-images* when we refer to the persistence of sensation after the stimulus has been removed. If it were not for after-images we could never combine the separate pictures of a cinema film into a continuous whole. *Negative after-images* are probably caused by fatigue of the retina. If we gaze fixedly at a red cross for a minute or so and then look up to the white ceiling we see a negative after-image in the shape of a green cross. The negative after-image is always the complementary colour of its positive. These phenomena, however, are not images in the strict sense of the word for they belong to the realm of sensation and perception. And an image must not be confused with a *primary memory image.* I can count the strokes of a clock after it has finished striking because of my primary memory image. This possibility is not in the category of an after-image. It needs a definite act of attention to arouse it.

Image. What then is an image? If the psychical processes involved in any sense perception are revived internally, *i.e.* without the aid of an external stimulus, we get an image. Obviously then nothing can be imaged unless it has previously been experienced; a child born blind can never have a visual image of the starry heavens or a sunset, nor can a deaf child image the strains of a musical composition. An image is thus a revived percept but this must not be thought to mean that an image is exactly like a percept; in many respects it is more like a ghost of a percept.

The tendency in modern psychology is to extend the meaning of the term to include "feelings of things, qualities and conditions of all sorts as not present. In this sense of the word there may be an image to correspond to every sensation, percept, impulse or emotion. There may be images of fatigue, fear, lonesomeness and tickling, as well as of faces and times."[1]

An image must not be confused with an idea. An idea is a higher mental process for it includes the meaning of the image as well as the image itself. If I image a house or even imagine a new house I get a totally different experience from the ideation of a house. The latter includes the meaning of the house, for example, its property of providing shelter. The relationship between image and idea is not unlike that existing between sensation and perception.

Attributes of Images. When compared with a percept an image is usually found to be dim, vague, blurred and incomplete. Various reasons have been put forward to account for this, but none are wholly satisfactory. According to some, the difference which normally exists is supposed to be one of degree in the original process, and may be attributed either to the reverse flow of the nervous discharge which causes the image (the reverse flow has not been proved) as compared with that which causes the percept, or to the weaker stimulus when the process is centrally initiated. According to others the theory that the representative process is concerned with a portion of the cortex different from perception explains the difference, while one investigator suggests that there is no real difference in intensity, but the stimulation of the nerves is continually being reinforced in the case of a percept by reference to the object actually present. Huxley explains the difference by the process of formation of an image. An image tends to be *generic* in character and this explains its general dimness and vagueness. He says.[2] "This mental operation may be rendered comprehensible by considering what takes place in the formation of compound photographs—when the images of the faces of six sitters, for example, are each received on the same photographic plate, for a sixth of the time requisite to take one portrait. The final result is that all those points in which the six faces agree are brought out strongly, while all those in which they differ are left vague; and thus what may be termed a *generic* portrait of the six, in contradistinction to a *specific* portrait of any one, is produced."

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[1] Thorndike: *Elements of Psychology*; p. 143.

[2] *Hume*: pp. 92-94. Quoted by James.

Most psychologists recognise this type of image, but Miller [1] denies that an image can be generic and states that it must from its nature be particular. If, however, one images a person who has been seen only on two or three occasions each time in a different suit, one certainly seems to have a distinct representation of the person's face, but his dress may be blurred and indistinct. Miller, however, recognises an abstract image, apparently intermediate in development between a generic image and a concept, in which the image plays a very subordinate part. A concept is thus built up through these different stages in the growth of an image.

Although some visual images are as clear as reality the number of these is far smaller than is generally supposed. We tend to exaggerate the clearness when we describe them. Let the reader who visualises easily call up the image of a well-known building in the city. Let him now try to count the number of the windows which look out on a certain street. Most people find the task impossible; the image is much more hazy than is usually anticipated. Few artists can paint from an imaginary model; and few persons possess the auditory imagery of a Beethoven or Mozart. Of the latter, it is stated, that when only fourteen years of age he heard Allegri's *Miserere* in the Sistine Chapel, Rome. This music had never been committed to paper. On his return home, Mozart, in the peacefulness of a slumbering household, wrote a faultless reproduction of the work.

The image is usually placed in space, but its situation varies among different individuals. In some instances the images seem to exist "in the eyeballs" or "in the head," while in others it is planted at a distance which corresponds to reality. My own visual images are of the latter variety.

If I image Leighton's "Last Watch of Hero" I feel the picture as hanging on a certain wall in the Manchester Art Gallery. It is next to impossible to get rid of this spatial element of the image. Further, I can walk about the room and the image remains stationary and quite independent of my changing percepts. If the thing I image is behind me, I invariably feel the image through the back of my head.

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[1] *Psychology of Thinking.*

Some people possess the ability to image the four walls of a room, or the six faces of a cube, at one and the same time.

The percept, we saw, was in the focus of consciousness and there it remained fairly steady, surrounded by a margin of imperfectly sensed objects. The image is also in the focus of consciousness, but unlike the percept, stands quite alone unsurrounded by peripheral elements of any description.

The more a memory image is examined the less distinct does it become. Dr. Ward[1] says that "it varies continually in clearness and completeness, reminding one of nothing so much as of the illuminated devices made of gas jets, common at fêtes, when the wind sweeps across them." Perky also finds them to be "exceedingly unstable as conscious content."[2]

Images also are usually flexible, although we may with difficulty picture an object in different positions or attitudes. We may never have been in an aeroplane, but we can imagine ourselves in the act of flying. Yet for most of us the task is difficult, because images retain their spatial attributes very tenaciously.

These distinctions serve to mark off the image from the percept. The nearer a person's images approach his percepts in vividness the more likely is that person to live in a dream world of his own. Children often confuse the image and percept. My young neighbour who told me yesterday that he had been eaten by a snake a mile long was not telling me a lie; he was merely confusing images and percepts. Even adults exaggerate the stories of their experiences and by oft repeating come to believe them as true.

Classification and Types of Imagery. Images are generally classified according to the percepts which caused them. We thus get visual images, auditory images, motor images, tactile images, gustatory images, and olfactory images. In addition, there are thermal images, organic images and emotional images; lastly there are verbal images in which the sound of the word is heard, or the motor process of articulation is reproduced, but no characteristics of the object which the word describes are conjured up. Verbal images are exactly the opposite of concrete images. Stout thinks that the higher modes of conceptual thinking are only possible by means of verbal images of words. Lately, a few German and American psychologists have declared their belief in the possibility of "imageless thought."

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[1] Article on *Psychology*; "Ency. Britannica," p. 58.

[2] Perky: *An experimental study of imagination*: Amer. Jour. Psy., XXI., 1910, pp. 422-452.

According to the type of dominant imagery, persons have been grouped into classes or types. Thus we get visiles (those whose visual images are especially strong), audiles, motiles, tactiles, etc. It is, however, quite unusual to find a person who is wholly dependent upon one form of imagery, *i.e.* pure visiles or pure audiles are almost unknown. Since modern civilisation emphasises the value of vision, visual imagery is far more common than other forms. Lay[1] analysing 2,300 recorded mental images of his own found that they were proportioned as follows :

	Per cent.		Per cent.
Visual - -	57·4	Tactile - - -	3·8
Auditory - -	28·8	Organic - -	1·1
Olfactory - -	5·9	Motor - - -	·3
Gustatory - -	·6	Emotional - -	1·0
Thermal - -	2·0		

Most individuals would be classed with Lay under a mixed type. Flinders Petrie, the Egyptologist, visualises so accurately that "he habitually works out sums by aid of an imaginary sliding rule, which he sets in the desired way and reads off mentally."[2] The chess players who can play, blind-folded, twenty or more games of chess simultaneously are probably endowed with extraordinary powers of visual imagery. For Zola, the novelist, "every object had its distinctive smell ; this was true of certain towns, such as Marseilles or Paris, and even of certain streets and of the different seasons of the year. The autumn, for instance, smelled of mushrooms and decaying leaves. In mental reproductions all these distinctive smells were revived vividly and distinctly. Zola was a pronounced olfactive."[1]

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[1] Lay : *Mental Imagery* ; pp. 36-37.

[2] Galton : *Inquiries into Human Faculty* ; p. 66.

Galton[2] was the first to carry out any elaborate research into imagery. He sent a long questionnaire to men of science and to school children both in England and America. Some of the questions related to auditory, olfactory, gustatory, tactile and other forms of imagery, but the main branch studied was visual imagery.

Part of his questionnaire was as follows:

"Before addressing yourself to any of the questions on the opposite page, think of some definite object—suppose it is your breakfast-table as you sat down to it this morning—and consider carefully the picture that rises before your mind's eye.

"1. *Illumination.*—Is the image dim or fairly clear? Is its brightness comparable to that of the actual scene?

"2. *Definition.*—Are all the objects pretty well defined at the same time, or is the place of sharpest definition at any one moment more contracted than it is in a real scene?

"3. *Colouring.*—Are the colours of the china, of the toast, bread crust, mustard, meat, parsley, or whatever may have been on the table, quite distinct and natural?"

Other aspects investigated were the extent of the field of view, the distance of the images, the command over images, the images of persons and scenery, the comparison with reality, the visual associations of numerals and dates, and the visual associations of any special aptitudes.

The following are typical replies to the questionnaire, divided into three groups according to the degree of vividness of the mental imagery:

High. "Brilliant, distinct, never blotchy."

"The mental image appears to correspond in all respects with reality. I think it is as clear as the actual scene."

"I can see my breakfast-table or any equally familiar thing with my mind's eye, quite as well in all particulars as I can do if the reality is before me."

Medium. "Fairly clear. Brightness at least one-half to two-thirds of original. [The writer is a physiologist.] Definition varies very much, one or two objects being much more distinct than the others, but the latter come out clearly if attention be paid to them."

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[1] Stout: *Groundwork of Psychology*; p. 113.

[2] *Inquiries into Human Faculty*; pp. 57-112, and Appendix E.

"Details of the breakfast-table *when the scene is reflected on* are fairly defined and complete, but have had a familiarity of many years with my own breakfast-table, and the above would not be the case with a table seen casually unless there were some striking peculiarity in it."

Low. "Dim and not comparable in brightness to the real scene. Badly defined with blotches of light; very incomplete."

"These questions presuppose assent to some sort of a proposition regarding the 'mind's eye,' and the 'images' which it sees. . . . This points to some initial fallacy. . . . It is only as a figure of speech that I can describe my recollection of a scene as a 'mental image' which I can 'see' with my 'mind's eye.' . . . The memory possesses it, and the mind can at will roam over the whole, or study minutely any part."

"My powers are zero. To my consciousness there is almost no association of memory with objective visual impressions. I recollect the table, but do not see it."

Galton thus shows that the powers of visual imagery have an exceedingly wide range and that in a few cases the images are as distinct as the original. But most of the images were, like Fechner's, "airy, unsubstantial and vaporous." In some cases the exact colours of the original objects are reproduced, in others the images appear in various shades of grey. Thus some of Galton's subjects could describe the actual colour of the china, coffee-pot, toast, etc., as seen on the breakfast-table.

Auditory imagery is next in importance to visual imagery. The ability to produce such images is largely dependent upon a slight or imaged movement of the muscles of the larynx and other articulatory organs. It is difficult, for example, to image the sound "bubble" with the mouth wide open. In this case we find auditory imagery very closely connected with images of movement. "Another motor element upon which the production of sound images depends is rhythm. It is a kind of solid skeleton, so to speak, which supports the tissues. It is doubtful if a continuous unvarying sound image can exist at all."[1]

Motiles are more numerous than is generally supposed. The motor images in writing, for example, are probably as important as the visual images. Hence it is profitable to allow young children to feel the movements necessary to form words and letters. Motor imagery is closely associated with images of touch.

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[1] Slaughter: *Mental Images*; Amer. Jour. Psy. XIII., p. 544.

Tactiles are chiefly found among the blind. Helen Keller must possess remarkable powers of tactile imagery. The dependence of the blind upon touch images is well illustrated in the case of the youth who, seeing geometrical figures for the first time after the restoration of his sight, had to feel the corners in wooden models before he could understand them.

Olfactory, gustatory and thermal images are seldom dominant enough in an individual to cause him to be dubbed an olfactive, gustative or thermile.

This division of persons into types—visiles, audiles, etc.—according to powers of mental imagery has been severely criticised by recent workers on the subject. Thorndike[1] thinks that dominance of one form of imagery is seldom met with and that instead we have one type only—mediocrity—with variations above and below. "Instead of distinct types there is a continuous gradation. Instead of a few 'pure' types or many 'mixed' types, there is one type—mediocrity. Instead of antagonism between the development of imagery from one sense and that from other senses there is a close correlation." Moreover the single mediocre type is universal in mental life.

"In the case of temperament, for example, we have the same history. Extreme cases are given names and made into types. Verbal contrasts are supposed to have real existence. Supplementary types are invented to help out the discrepancies between the imagined types and the real distributions of individuals. And it is highly probable that, when actual measurements are made, mediocrity—a temperament moderately sanguine, choleric, phlegmatic and melancholy; moderately slow, quick, shallow, intense, narrow and broad, moderately slow-shallow slow-intense-narrow; moderately *everything*—will be found to be the one real type."

Thorndike uses as his illustration of his "single" type theory, as opposed to the "multiple" type theory, a model corresponding to a normal distribution curve rotated upon its vertical axis to form a solid figure in three dimensions. This figure will have the appearance of a relief map. With the single type, "the whole relief map would look like a mountain, with, possibly, many radiating and cross ridges, casual valleys and eminences, but with, always, a decreasing elevation, the larger the radius of a circle drawn about the summit. By the multiple type theory, the average elevation need bear no relation to the distance from the centre spot; the depressions would be between the several peaks each representing a type. In proportion as the types were held to be very sharply distinct and widely separated, these intervalleys would be deep, even to the original surface, and wide."

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[1] Thorndike: *Educational Psychology*; 1910 Ed., pp. 193-204. See also Betts: *The Distribution and Functions of Mental Imagery*; 1909.

Four arguments are adduced in favour of the single type theory: (1) That wherever measurements, as opposed to mere speculations, have been made, they are invariably in favour of the single type theory. (2) That the multiple type theory presupposes inverse correlations between desirable traits and these are extremely rare. (3) "That the single traits involved are so often distributed each approximately symmetrical around one mode and that their intercorrelations are so often approximately rectilinear." (4) That persons who believe in the multiple type theory find so few actual cases to support their position.

Yet Thorndike is compelled to acknowledge that environment may develop certain traits so largely, while leaving other traits undeveloped, that persons may "cluster around a type of their own." Hence there may appear "many minor eminences upon our relief map of human nature due to influence of 'nation lived in' 'language spoken,' 'occupation followed,' and the like."

Productive and Reproductive Imagination. Our discussion, up to the present, has been concerned chiefly with images which were fairly faithful representations of the actual sense-perceptions. For this reason the term *reproductive* imagination has been given to the process. But as we saw in our preliminary discussion these memory images may be freely disintegrated and the elements re-combined to form situations which have not previously been realised. The elements of which these re-organised images are composed have, however, close connections with reality. If the reader were asked to draw an animal which did not exist, say a gryphon, he would probably use parts of animals well known to him and re-combine them into a new whole. This re-combination of images is known as *productive* imagination. Baldwin[1] distinguishes two kinds of productive imagination. One kind is "dominated by a systematic unity of plan controlling the process of selective combination." This active type may be termed constructive or creative imagination. Thus a child, when trying to make the design for the back of a book, first thinks of the different designs he has seen on books and of the various elements of design he has seen used. He then works over this stock of images, selects those he thinks suitable, and from them, in imagination, constructs a design which he has not actually seen before. This image forms the basis of his work in ornamentation. The other kind is much more passive and has no definite purpose. It is often called "fancy." Fancy is free to form one combination after another, which may have little or no connection with each other. It possesses a feeling-tone of a more pronounced character than creative imagination. And the feeling-tone, if the play of the imagination is uninterrupted, is usually a pleasant one.

Growth of Imagination in Children. Reproductive imagination develops before productive imagination in children. So far as we know, young children below 2½–3 years cannot voluntarily form any kind of images. At four or thereabouts productive imagination of a most intense kind seems to develop. The child cannot always distinguish fact from fancy; percepts and images are often confused and the well-known lies of children are the results. The large part that productive imagination plays in his life is seen in his plays and games.

Imagination makes a block of wood into a soldier, a match into a boat; and a shawl, pillow or clothes-peg into a doll.[2] The make-believe in doll-play is a tribute to the strength of imagination of girlhood. To dolls are ascribed all the physical and psychic qualities of living human beings. They may be good, bad, angry, naughty, loving, tired, proud or stubborn; they require food and can take it gracefully at table; they need sleep and often have to be soothed with lullabies; they often fall sick and need the attentions of a doctor; and they sometimes so far forget themselves as to die.

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[1] Baldwin: *Encyclopaedia of Psychology*: p. 571.

[2] See Hall: *A study of Dolls*, in "Aspects of Child Life"; Chap. V.

The child himself may be the subject of his imagination; he may become a dozen different persons in a day. He is first an engine-driver with an inverted chair for a train. Tired of this, he becomes a doctor, visits the sick, and even aspires to perform operations. He retires to rest at night as a highway robber and hides beneath the counterpane from the policeman who pursues him. And in the morning he may arise as plain Johnny Jones.

He lives in a world of make-believe and with his increase of perceptual experiences his supply of images for conversion into imaginative pictures largely increases. The great period for fairy tales is reached at 7 or 8. But with advancing years the distinction between fact and fancy is more clearly recognised. Fairy tales are cast aside only to be replaced by romance, travel and adventure. And with the onset of adolescence develops the power for idealisation of heroes. Hero-worship now becomes common and this naturally leads on to the disciplined imagination of later adolescence which creates the poet, the inventor, and the artist as well as the leader of men.

Meanwhile, from childhood onwards, he has been subject to a form of imagination (where a peculiar automatism of the image is observed) known as day-dreaming.[1] At 7 or 8 years of age he was probably the chief actor in some great game of life. Dreams of wealth and immense power gave a roseate hue to some of the drab hours of existence. A little later, dreams of travel and of military and naval exploit would find a place on his stage; and at 16 or 17 the dreams would take on such practical aspects as those of home-building and of future occupations.

The powers of imagination seem to decline with age. Vivid visual and accurate auditory images are replaced by the much more useful verbal images. Stout believes that verbal images are necessary to thinking and that this accounts for their increase with age.

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[1] See Smith: *Psychology of Day Dreams*; in Hall's "Aspects of Child Life." The imagery of all dreams (sleep dreams included), be they never so fantastic, can be traced back to the percept of the waking state. And no "Utopia" is so far removed from actuality that its materials have not been dug from the quarries of perception.

Mrs. Mumford[1] points out that practical and ethical difficulties may arise with highly imaginative children: "(1) That 'play-acting' and dreaming often take the place of doing; and (2) That they often get into the habit of beginning, and not finishing." These dangers are real ones, but the danger of killing off imagination is even greater. All the really great things of life are products of the imagination; nay further "the whole progress of the human race," as Welton says, "has been due to its imagining of better things and its efforts to make those imaginings real."

Tests of Imagination. The experimental investigation of imagination presents serious difficulties. Up to the present, indirect tests have been most frequently applied. The investigations of the fidelity of reports, or of the validity of testimony, give interesting side-lights upon the mental imagery of the subject.

A more direct test of the imagination is the ink-blot test. The test was devised as a substitute for the ephemeral clouds of a summer's day which are most easily imagined to be so many fantastic objects. Chance blots of ink are made by pressing with the finger a drop of ink between two squares of paper. These squares are mounted on cardboard and arranged so that the same view is presented to each subject.[2] Each subject is told always to look at the blot-card the right side up, neither turning the card nor the head, to tap sharply at the moment at the consciousness of the first suggested image, and to report each concrete object suggested as concisely as possible.

The individual differences of the imagination are great, and as a rule the immediate past experiences determine the form of the imagery. Dearborn found that a single ink-blot gave the following images with six subjects—a cabbage head; an animal with its mouth open; a fairy in a cloud; a woman seated, with a basket in her lap; top of Indian's head with the nose swollen; and a grotesque Indian's head.

Younger children are more imaginative than older ones and they are more prone to believe that the ink-blot actually represents the object they see in it.

Other tests of imagination are the various tests of linguistic invention and the completion method of Ebbinghaus.[1]

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[1] Mumford: *Dawn of Character*; Chap. IV.

[2] Dearborn: *A study of imaginations*; Amer. Jour. Psy., IX., 1898, 183-190.

In the development of sentences tests the subject is asked to write as many sentences as possible containing the three nouns, say, *citizen, horse* and *decree.* Each sentence is to contain all three words and they are to be as varied as possible. For example "a decree was posted that the citizen should not abuse the horse" and "The horse of the citizen was sold by official decree" are both regarded as satisfactory. The judgment of the results is far from easy. In general, it is found that the subjects who make the most sentences make also the most elaborate, and those who make the fewest sentences make also the simplest and most unimaginative ones.

The word-building test is similar in character. The subject is asked to make as many words as possible from any or all of six letters, *e.g.—a, e, o, b, m, t*, or *e, a, i, r, l, p.*

Ebbinghaus's completion method is also known as the mutilated text test. From a passage of prose certain words or parts of words are deleted and replaced by lines. The pupil has to fill in the blanks so that the passage makes sense. The ability to do the test improves with age, and many factors besides imagination enter into it.

The interpretation of fables is similar in its results to the mutilated text test.

Further tests of imagination are needed before any reliable conclusions can be drawn. The subject, however, is an important one for the educator. Imagery largely influences conduct. Many a wrong action is done because of the inability to realise its outcome, *i.e.* to image its result. What youth would ever cross the threshold of a public-house if he could image, vividly and really, the future ruined life? The development of a good stock of images is the basis of all intellectual progress. To leave the development of the imagination to the weekly penny dreadful or to mere chance is sadly to neglect our duties as teachers.

References. Betts: *The Distribution and Functions of Mental Imagery*: Columbia Univ. contrib. to Ed., 26. Binet and Henri: *La Psychologie Individuelle*; Année Psychologique, II., 411-465. Dearborn: *Blots of Ink in*

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[1] Whipple: *Manual of Mental and Physical Tests*; Chap. XI.

Experimental Psychology; Psy. Rev., IV., 390-1, 1897. Dearborn: *A Study of Imagination*; Amer. Jour. Psy., IX., 183-190, 1898. Galton: *Inquiries into Human Faculty*; pp. 57-79. James: *Principles of Psychology*; Chap. XVIII. Kirkpatrick: *Individual Tests of School Children*; Psy. Rev., VII., 274-280, 1900. Mumford: *Dawn of Character*; Chap. IV. Rusk: *Introduction to Experimental Education*; Chap. VII. Sharp: *Individual Psychology: A Study in Psychological Method*; Amer. Jour. Psy., X., 329-391, 1899. Stout: *Manual of Psychology*; p. 409-436. Thorndike: *Elements of Psychology*; Chap. III. Thorndike: *Notes of Child Study*; Chap. X. Whipple: *Manual of Mental and Physical Tests*; Chap. XI.

CHAPTER XVI.

THE EMOTIONS.

Definition of Emotion. Psychologists usually maintain that every mental act presents, at one and the same time, three aspects, namely, a *cognition* or knowing aspect, an *affection* or feeling-tone, and a *conation* or a striving which only ceases when a satisfactory end-state is reached.

An emotion is a state of consciousness in which the feeling-tone is predominant. Some sensations possess more feeling-tone than others, and those from the internal bodily organs are most important in this respect. Indeed we may go so far as to say that the sensations which tell us most about the outside world are least likely to possess much feeling-tone; while those that tell us least, hardly ever come into consciousness except as vital parts of emotions. Emotions, then, are chiefly aroused by organic sensations, or, at least, are invariably accompanied by them.

Since the feeling-tone plays such a large part in emotions, it follows that they are strongly subjective in quality; they have a personal reference as opposed to an objective one. Yet an object is necessary to an emotion. We do not feel in the abstract, but we feel for, or about, something or somebody. Hence an emotion may be defined as "the feeling of a subject towards an object" (Stout); or as "a tendency to feel characteristically when in the presence of a certain object in the environment."

Characteristics of Emotion. The most obvious characteristic of an emotion is its bodily expression. We *see* when a man is angry, sorrowful, or full of fear. Darwin[1] wrote a book of almost 400 pages descriptive of the expression of the various emotions. The following is an abridgment of his description of *rage* or intense anger :

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[1] Darwin: *The Expression of the Emotions in Man and Animals*; 1st ed., 1872, 2nd ed., 1890.

> "Rage exhibits itself in the most diversified manner. The heart and circulation are always affected ; the face reddens or becomes purple, with the veins on the forehead and neck distended. . . . With one of my own infants, under four months old, I repeatedly observed that the first symptom of an approaching passion was the rushing of the blood into his bare scalp. On the other hand, the action of the heart is sometimes so much impeded by great rage, that the countenance becomes pallid or livid, and not a few with heart-disease have dropped down dead under this powerful emotion.
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> "The respiration is likewise affected ; the chest heaves and the dilated nostrils quiver. . . .
>
> "The excited brain gives strength to the muscles, and at the same time energy to the will. The body is commonly held erect for instant action, but sometimes it is bent forward towards the offending person, with the limbs more or less rigid. The mouth is generally closed with firmness, showing fixed determination, and the teeth are clenched or ground together. Such gestures as the raising of the arms, with the fists clenched, as if to strike the offender are common. Few men in a great passion, and telling some one to be gone, can resist acting as if they intended to strike or push the man violently away. The desire, indeed, to strike often becomes so intolerably strong, that inanimate objects are struck or dashed to the ground ; but the gestures frequently become altogether purposeless or frantic. Young children, when in a violent rage, roll on the ground on their backs or bellies, screaming, kicking, scratching, or biting everything within reach. . . .
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> "But the muscular system is often affected in a wholly different way ; for trembling is a frequent consequence of extreme rage. The paralysed lips then refuse to obey the will, 'and the voice sticks in the throat' ; or it is rendered loud, harsh, and discordant. If there be much and rapid speaking, the mouth froths. The hair sometimes bristles. . . . There is in most cases a strongly marked frown on the forehead, for this follows from the sense of anything displeasing or difficult, together with concentration of mind. But sometimes the brow, instead of being much contracted and lowered, remains smooth, with the glaring eyes kept widely open. The eyes are always bright or may, as Homer expresses it, glisten with fire. They are sometimes blood shot, and are said to protrude from their sockets—the result, no doubt, of the head being gorged with blood, as shown by the veins being distended. . . .
>
> "The lips are sometimes protruded during rage in a manner, the meaning of which I do not understand, unless it depends

on our descent from some ape-like animal. . . . The lips, however, are much more commonly retracted, the grinning or clenched teeth being thus exposed. This has been noticed by almost every one who has written on expression."

The emotion of rage may be taken as typical of emotions in general. The most characteristic expressions of emotions are connected (1) with changes in the blood circulation; (2) with changes in the breathing; (3) with disturbances of the secretions (tear glands and sweat glands); (4) with movements of involuntary muscles; and (5) with marked variations in the muscular strength of the body. The first three are easily observable, but it is difficult to notice movements of involuntary muscles, except when they cause shivering or raising of the hair, and almost impossible to prove that the bodily strength is altered. By means of X-rays it can be shown that the stomach movements of a cat are inhibited by anger. There is recorded the story of a boy who, when chased by a bull, jumped a fence which he could not jump again in an un-emotional state until he was several years older.

Closely allied with the expression of the emotions are the changes of electrical potential in the body and increase or decrease of the reflex knee-jerk by different emotional stimuli. The former is measured by connecting two points on the skin to a delicate galvanometer and reading off the deflections. "Veraguth found that if a story were read to a subject while his skin was connected with the galvanometer, deflections occurred when emotional passages were read."[1] The knee jerk is increased by martial music and decreased by interesting music. The cry of a baby increases the reflex, while commonplace noises, such as the rattle of wheels in the street, have no effect.

The second characteristic of emotions is their early development and their persistence throughout life. Thwarting a baby, by preventing him from moving a finger, is sufficient to cause an emotional outburst of anger as early as the first four months of life. This early development of emotions seems to be due to an evolutionary survival. Animals fairly low down in the scale exhibit many of the coarser emotions. The close connection between emotion and instinct indicates a possible explanation of the phenomenon. Moreover, emotions persist throughout life, although the emotional feelings of the octogenarian are neither so rich nor so varied as those of the adolescent.

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[1] Ladd and Woodworth: *Elements of Physiological Psychology*; p. 509.

The third characteristic is their wide range and easy arousal. Practically anything may excite fear in a child. There is not just one thing that makes him afraid, but several; and the ease of the arousal from varied sources is often a sore trial to the adult. The emotion of fear is, however, felt at every stage of mental development. A child of three months may be afraid of falling, while a man of forty may be afraid that a loved one is going to die.

The fourth characteristic is that they interfere with judgment. We do and say things under the influence of emotion which subsequent sober reflection declares to have been stupid. Emotions "master us"; they refuse to be used "for intellectual or practical ends." To count ten before answering when angry is good advice, even if it is difficult to put into practice. For the same reason punishments should always be meted out to children in cold blood.

The fifth characteristic is their persistence when once aroused. An angry man is usually angry for a long time, he refuses to cool down and vents his anger right and left on both the innocent and the guilty. A child sobs on his mother's breast long after he has discovered that the fearful ogre is only his brother disguised with a mask.

The sixth characteristic is their difficulty of reproduction in imagery. If we try to imagine ourselves angry, afraid, or overwhelmed with grief the attempt is usually a sorry one. We may know that we were afraid of burglars last night, but it is difficult to image the palpitation of the heart which was one of the symptoms.

The seventh characteristic is their incoherent nature. Spiller[1] tried to analyse an emotion. He found himself trying to steer a boat for the first time in his life, when the River Cherwell at Oxford was crowded with craft. The emotion of anxiety became highly developed, and this emotion he examined while steering. He found himself in a state of great perplexity, he wanted to do more than one thing at a time—wished to settle several difficulties at once—and hence his ideas, most of which were killed before they emerged, seemed to scurry to and fro. There was no serene statement, "I am perplexed as to what I shall do." Instead, a crowd of incomplete thoughts was presented and vain and repeated attempts made to find solutions. The emotion was incoherent; it was "a mental attitude in a state of excitement."

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[1] Spiller: *The Problem of the Emotions*; Amer. Jour. Psy., XV., pp. 569 ff.

Any other emotion if analysed would present the same incoherent, illogical characteristics.

The connection between Instinct and Emotion. The connection between instinct and emotion has long been recognised as a close one, *e.g.* love, jealousy and fear are indiscriminately described as both instincts and emotions. Perhaps some of the terms are misapplied, but McDougall[1] has worked out a series of definite connections between certain instincts and emotions.

1. *The instinct of flight and the emotion of fear.* "The instinct to flee from danger is necessary for the survival of almost all species of animals, and in most of the higher animals the instinct is one of the most powerful. . . . These locomotory activities are accompanied by a characteristic complex of symptoms, which in its main features is common to man and to many of the higher animals, and which, in conjunction with the violent efforts to escape, constitutes so unmistakable an expression of the emotion of fear that no one hesitates to interpret as such; hence popular speech recognises the connection of the emotion with the instinct that determines the movements of flight in giving them the one name *fear*."

2. *The instinct of repulsion and the emotion of disgust.* The instinct of repulsion is closely allied to that of fear but differs from it in its mode of expression: fear causes retreat, while repulsion prompts advance so that the offending object may be removed. Evil tasting things are rejected, and slimy things cause "creepy" shudders. Whenever the instinct of repulsion is aroused the emotion of disgust is its invariable accompaniment.

3. *The instinct of curiosity and the emotion of wonder.* Wonder is here used as a simple or primary emotion. Curiosity is aroused by things which are new and strange, but which are not sufficiently new and strange to excite fear.

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[1] *Social Psychology*; Chap. III.

4. *The instinct of pugnacity and the emotion of anger.* The instinct of pugnacity "occupies a peculiar position in relation to the other instincts . . . for it has no specific object or objects the perception of which constitutes the initial stage of the instinctive process. The condition of its excitement is rather any opposition to the free exercise of any impulse, any obstruction to the activity to which the creature is impelled by any one of the other instincts. And its impulse is to break down any such obstruction and to destroy whatever offers this opposition." The instinct, and therefore its accompanying emotion, is especially strong in the males of the species. And it is stronger in the young and undisciplined than in the old. Young children are notoriously pugnacious and prone to anger.

Other more or less close connections have been worked out by McDougall, *e.g.*:

5. *The instincts of self-abasement and of self-assertion and the emotions of subjection and elation*; 6. *The parental instinct and the tender emotion*; 7. Other instincts of less well-defined emotional tendency, such as the instinct of *reproduction* and the emotions connected with sex; the gregarious instinct and the emotions of (?) [non-lonesomeness]; the instinct of *acquisition* and the emotion of (?) [possession]; the insfinct of *construction* and the emotion of (?) [certain feelings which invariably accompany the exercise of the instinct and especially the satisfaction at the completion of the task in hand. No name has been given to it].

The close connection between emotion and instinct is indicated by a probable common origin. Certain it is that the coarser emotions in animals (and in our far-off ancestry) are invariably associated with the specific instincts enumerated above. If one is not the cause of the other, there is good reason to suppose that they are simultaneous effects of a common cause.

Again many of the bodily expressions of the emotions are instinctive actions which are reminiscent of ancestral ways of life. Consider the method of expressing fear. In addition to the bodily disturbances such as palpitation of the heart, the breaking out into a cold sweat, the trembling of the limbs, the raising of the hair and the difficulty with breathing, we have the following instinctive movements: the eyes are opened widely, the eyebrows are raised, the subject crouches as if to escape observation and the arms are often extended as if to ward off a blow.

So close is the connection that James (1884) and Lange (1885) each, independently, put forward a theory which explains the coarser emotions, at least, on the basis of the organic disturbances that arise as the result of instinctive actions.

James-Lange Theory of Emotions. The theory is propounded by James in the following terms : [1]

"Our natural way of thinking about these coarser emotions (grief, fear, rage, love) is that the mental perception of some fact excites the mental affection called the emotion, and that this latter state of mind gives rise to the bodily expression. My theory, on the contrary, is that *the bodily changes follow directly the perception of the exciting fact and that our feeling of the same changes as they occur* is *the emotion*. Common sense says, we lose our fortune, are sorry and weep, we meet a bear, are frightened and run, we are insulted by a rival, are angry and strike. The hypothesis here to be defended says that this order of sequence is incorrect, that the one mental state is not immediately induced by the other, that the bodily manifestations must first be interposed between, and that the more rational statement is that we feel sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike, tremble, because we are sorry, angry, or fearful, as the case may be. Without the bodily states following on the perception, the latter would be purely cognitive in form, plea, colourless, destitute of emotional warmth. We might then see the bear, and judge it best to run, receive the insult and deem it right to strike, but we should not actually *feel* afraid or angry."

According to James therefore the order of events is : (1) perception of object ; (2) instinctive action leading to various organic disturbances ; (3) the experience of the emotion ; while ordinary common sense reverses the order of (2) and (3).

The arguments in favour of the James-Lange theory are :

(1) The well-known and close connection which exists between instinct and emotion (*supra*).

(2) Every bodily change arising out of instinctive or

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[1] James : *Principles of Psychology* ; II., p. 449.

other movements " is felt, acutely or obscurely, the moment it occurs."

(3) If the organic sensations or instinctive movements are taken away from an emotion nothing is left. "If we fancy some strong emotion, and then try to abstract from our consciousness of it all the feelings of its bodily symptoms, we find we have nothing left behind, no 'mind-stuff' out of which the emotion can be constituted, and that a cold and neutral state of intellectual perception is all that remains."

(4) If we put ourselves in certain bodily attitudes we tend to experience corresponding emotions. If we bare our teeth, clench our fists, open wide our eyes and throw the body forward, it is almost impossible not to feel angry. In the same way, if we kneel with clasped hands, bowed head and closed eyes, it is practically impossible not to feel "religious."

(5) A questionnaire sent around to various famous actors by William Archer. elicited the information that about half of them experienced real emotions while acting on the stage—real anger, real sorrow, real joy was felt; real tears were shed. real sobs and real laughter were made.

Against the theory the following arguments have been adduced:

(1) The time factor is a serious one, for the length of nerve tract to be covered is great in the case of the James-Lange theory. The emotion is the "back-stroke" of the action. When we experience fear we do not appear to "jump" before we feel the emotion. The two things seem to occur simultaneously. On the other hand, if we can remain calm and refrain from jumping we do not feel fear.

(2) It is not every organic sensation that excites an emotion. The feeling-tone of a delicious hot bath is very great, but one could hardly call it an emotion. The emotion is only aroused when there is an interference with a pre-existing conative tendency.

(3) Because two things—organic sensations and emotion—invariably occur together it does not necessarily follow that one is *cause* and the other *effect*. As was pointed out earlier in the chapter, they may both be effects arising from a common cause.

(4) The theory does not take into account the previous

disposition of the subject. In some moods, the least disturbance makes us angry or annoyed. In other and more joyous moods, nothing that happens can upset our equanimity, in fact, annoyances are translated into actual pleasures.

(5) In a similar way it does not account for what Thorndike calls a pseudo-emotion. While at the theatre, we may weep at the sorrows of the heroine on the stage, but it is a very different grief from that caused by a real happening; we know the thing is make-believe.

(6) Certain emotions are aroused inwardly. We may experience anger by thinking of the wrongs of the previous day. But "the primary disturbance, being the precondition of the organic reaction, cannot be regarded as its effect." This type of emotion, however, is generally weaker than the kind which is aroused externally.

These difficulties in the way of a complete acceptance of the theory have led to numerous modifications. McDougall accepts the theory providing it is modified to include the possibility of "revived or reproduced organic sensations, without the intervention of actual visceral changes," producing emotions.[1] Spiller thinks that James is right in arguing that physical excitement is present in every emotion as an essential constituent, but he also maintains that emotion implies mental excitement—a more or less broken or hurried stream of thought tending to mental and bodily chaos when the excitement is great. He therefore seems to belong to the group who state that the emotion and the bodily excitement are simply two aspects of a particular kind of mental process. These modifications change the theory to such an extent that it becomes to all intents and purposes a new one.

The Central Theory of Emotions. This theory is propounded by Ladd and Woodworth,[2] who use the term *central* in contradistinction to the *peripheral* theory of James. They state:

> "A not unreasonable conjecture as to the central conditions on which the excitement of the more complex forms of emotion are dependent, would state the case in somewhat the following way: It is a well-known fact the different individuals differ

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[1] McDougall: *Physiological Psychology*; p. 114.

[2] *Elements of Physiological Psychology*; pp. 522 ff.

more widely and incalculably as to the particular feelings evoked, on different particular occasions, than as to the sensations and ideas occasioned by changes in the amounts, kinds, and time-rates of the stimuli which act upon the peripheral nervous system. This fact suggests that our feelings are determined by the changeable relations of the neural processes to the constitution, previous habits and temporary mood of the nervous system, and by the relations of each neural process to all the others within the central system, in a more irregular way than are our sensations and our knowledge. Those conditions of the nervous processes which depend immediately upon the quality, intensity, and time-rate of the stimuli that act upon the end-organs of sense, are in general conformable to law ; they are regular and—as it were—to be depended upon. In correspondence with them are the regularity and the dependableness of our sensations and of our knowledge by the senses. But over and above the more uniformly recurrent similar elements in all the peripherally originated nervous processes, there is more or less of a 'semi-chaotic surplus' of nervous action occasioned in the brain centres. In this semi-chaotic surplus—the general character of which depends upon what the whole nervous system was, and is, and has recently been doing, and upon how the various new stimulations, running into the brain centres, fit in with all this and with one another—may we find the physiological conditions of the emotions. No wonder, then, that these conditions are so indeterminate for different individuals, and so changeable in the same individual. At any particular moment the kind and amount of feeling experienced has for its physiological condition the total complex relation in which all the subordinate neural processes, set up by the stimuli of that moment stand to one another and to the set, or direction, of the pre-existing neural processes."

According to this theory it is the semi-chaotic surplus of nervous action which causes the emotion. The theory explains certain features connected with emotions very clearly, *e.g.* the hurrying of the thoughts, the general perplexity, the intense excitement, the incoherency and so forth. It also explains the influence of the pre-disposition of emotions, but it does not explain why some objects arouse emotions and others do not. Nor does it account for the inhibition of emotion by the control of bodily movement.

The reader will have noticed a similarity between this theory of emotion and the explanation the authors adduced to account for the phenomenon of association (see Chapter X.). In the one case we have a "semi-chaotic surplus of nervous action," and in the other a "heightened excitability" which follows a nervous discharge.

Classification of Emotions. James classifies emotions into *coarser* emotions (anger, fear, love, hate, joy, grief, shame, pride), and *subtler* emotions (moral, intellectual and aesthetic feelings).

Stout uses the terms *primary* (anger, fear, grief, joy and surprise) and *derivative* (pity, admiration, gratitude, remorse and wounded vanity). McDougall, meaning the same thing, uses *primary* and *complex*.

Titchener divides them into *qualitative* emotions—those in which the aspect of quality is reflected, and *temporal* emotions—those in which the time element is important. Of the former, we get as examples joy, sorrow, sympathy, like, dislike, antipathy and attraction. Of the latter expectation and surprise are the fundamental ones. In another place, Titchener divides them into *pleasurable* and *unpleasurable*.

Thorndike speaks of *real* emotions and *aesthetic* emotions. The aesthetic emotions are subdivided into *sensory pleasures* and *pseudo-emotions*. The pseudo-emotions have been much discussed. "The sorrow felt for the suffering hero is unlike real sorrow (1) in that one does not rush around wringing his hands and seeking to offer help nor feel like doing so, and (2) in that, whereas real sorrow is very uncomfortable, the pseudo-sorrow of the reader of the story is more or less enjoyable." In some cases, as when an illiterate sees a play, the pseudo-emotion becomes closely allied to a real emotion. A pseudo-emotion of this kind seems to be experienced sometimes at the Zoo when a caged animal makes a sudden spring at the bars, or gives vent to a sudden roar. We are frightened but our fear is not at all comparable to the real heart-gripping emotion of fear.

Westermarck[1] divides up the moral emotions into two classes—*disapproval*, or indignation, and *approval*. The relationship existing between them is shown by the following chart:

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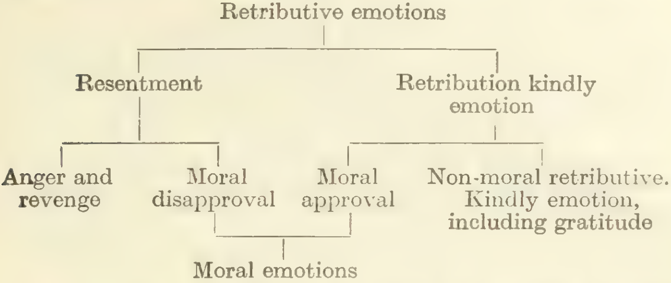
[1] Westermarck: *The Origin and Development of Moral Ideas*; Chap. II. This chapter, which is very controversial in its nature, forms the basis of the whole treatise.



The various classifications adopted by different writers show that there is not a fundamental difference between emotions; all the classifications are therefore arbitrary.

Emotion and Mood. A mood is distinguished from an emotion by (1) Its duration. "A mood is a 'long-drawn out' emotion." (2) Its intensity. In comparison with an emotion it seems more "dilute"; it is to an emotion as an element in the margin of attention is to one in the focus. Thus its feeling-tone is much less than that of an emotion. (3) Its lack of a distinct "object."

Emotions often fade into moods, or have moods as aftermaths. In the same way a mood may "flare up" into an emotion. From one point of view a mood is simply a succession of little emotional outbursts.

Change of Emotions with Age. The emotions of man seem to exhibit two maximal periods, the first at the age of 4-5 and the second during adolescence. From adolescence onwards the emotions wane with men, and also with women except for the emotional outbursts consequent upon motherhood. On the whole, however, the emotions of children are stronger than those of adults. They are also more fickle and variable: tears, for example, are often very near to laughter. The waning of the emotions seems to be due to the increasing rationality of life which comes with age. It is impossible to yoke calm judgment and wealth of emotional life in one and the same person. The amenities of civilised life also tend to kill off the emotions. "Washing, cooking, going to school and church, making shoes or overcoats or steel rails, buying and selling, eating regular meals or sleeping in fire-proof buildings with locked doors and watchmen, are occupations not conducive to a vigorous emotional life."[1]

The outburst of emotional life at adolescence is connected with the development of the powers of sex. It exhibits a very wide range and there is a curious instability about it. Alterations of feeling take place with unpleasant frequency. Selfishness alternates with altruism, conservatism with iconoclasm, and self-confidence with humility, in the most embarrassing fashion. This emotional instability, coupled as it is with profound bodily changes, is sometimes a source of moral danger. On the other hand, it is the mainspring of the enthusiasm for ideals which is one of the marked features of adolescence.

References. Angell: *Psychology*; Chaps. XIII., XIV., XVIII., XIX. Betts: *The Mind and its Education*; Chaps. XII., XIII., XIV. Calkins: *A First Book of Psychology*; Chaps. XI., XIII. Darwin: *Expression of the Emotions.* James: *Principles of Psychology*; Chap. XXV. Judd: *Psychology*; Chap. VII. McDougall: *Physiological Psychology*; Chap. VI. Ribot: *Psychology of the Emotions.* Seashore: *Elementary Experiments in Psychology*; Chap. XV. Titchener: *A Primer of Psychology*; Chaps. I., VIII., XII. Thorndike: *Notes on Child Study*; Chap. XIV. Thorndike: *Elements of Psychology*; Chap. V. Thorndike: *Principles of Teaching*; Chap. XII.

[1] Thorndike: *Notes on Child Study*; p. 103

SECTION V.

CHAPTER XVII.

THE PSYCHOLOGY OF BABYHOOD AND ADOLESCENCE.

Although the emphasis throughout this book has been placed on the mental and physical life of children at school, the periods of babyhood (birth to 4 or 5) and early adolescence (12-18) cannot be neglected. In order to understand a child at school some knowledge of his pre-school life is essential. Since the majority of children leave school before reaching the age of fourteen, only the beginnings of adolescence can be legitimately included under school-life, yet the supreme importance of this period from an ethical and social point of view, merits its careful consideration. An attempt will therefore be made to describe some of the characteristics of these periods.

BABYHOOD.

Physical. At birth a baby averages 7 lbs. in weight and 19·5 inches in height. The weight of a boy is one-twentieth of his adult weight, while that of a girl is a little more than one-seventeenth. The variability in weight at birth is much greater than that of height since the range for the former is from three to sixteen lbs. The weight trebles during the first year and the height increases 7 or 8 inches. The weight at the end of babyhood (4-5 years) is five times as great as at birth, while the height has doubled both for boys and girls.

The muscles of the hands and feet concerned with grasping and the muscles of the mouth concerned with sucking are the first to be controlled. Following the development of these are the muscles which turn the eyes, the larger muscles of the arms and legs, the muscles which turn the head, and the muscles of the back concerned with an upright sitting posture. Towards the close of the first year, the muscles for creeping, standing and walking and the finer muscles for articulation are rapidly brought under control. All these muscles are fully co-ordinated at the end of babyhood ; the muscles concerned with the finer movements and adjustments of the limbs are still undeveloped, and hence such tasks as writing, painting and sewing should not be undertaken at this time.

The stomach during the first year of life is almost purely carnivorous in size and shape. The cutting teeth (meat) also appear before the grinding teeth (starch). Twenty milk teeth ordinarily make their appearance before or just after the close of the second year. The time of cutting the milk-teeth is generally as follows :

The two lower central incisors, 6-9 months.
The four upper incisors, 8-12 months.
The two lateral lower incisors and the four anterior molars, 12-15 months.
The four canine or eye-teeth, 18-24 months.
The four back molars, 24-30 months.

It must be remembered that the time of teeth cutting, and even the number of teeth, varies with different children. Some babies are born with one or two incisor teeth already cut, while others do not cut the first incisor until they are twelve months old.

The brain of a boy at birth is 12·3 per cent. of the weight of his body, or about $\frac{1}{3}$ of what it will ultimately attain. It also grows very rapidly and at seven is almost fully grown. Development, however, is much slower than growth. It is tolerably certain that the greater part of the cortex is inactive during the first three months of life. The fibres become functionally active and myelinate in a fairly constant sequence.

The death-rate of children is a fairly good indication of their liability to disease. About 10 per cent. of babies die during the first year of life. In most civilised countries this high proportion is rapidly diminishing owing to the increased attention which is being paid to sanitation and to the proper care of babies. Still it is a lamentable fact that one child in 5 dies before the end of babyhood. The chief ailments of babies are those connected with disturbances of digestion. The disturbances of sleep—dreams, talking in sleep, night terrors and snoring—while hardly falling under the category of diseases are detrimental to the general health. In the first five years of life the beginnings of such defects as flat feet, weak ankles, bow-legs, impaired vision, and weak lungs are often made.

The sense organs chiefly develop during the first few months of babyhood. As their use depends upon a corresponding development of the mental powers it is perhaps unwise to class them under the heading "physical."

From the very first days of its life a baby can tell the difference between light and darkness and does not like to be placed in front of a bright light. A very bright light is especially painful immediately on awakening. This sensitiveness to light persists and is very common among adults. The pupils of a young baby will contract when light is thrown on them. But a new-born baby cannot see *things* in the proper sense of the term. This power is of later development. He will, however, notice things and people and follow them with his eyes before the middle or end of the second month. The mother, especially if she is feeding the baby herself, will probably be recognised and identified about the middle or end of the third month. Other persons and things are recognised during the fifth month.

Preyer has divided the "seeing" of a baby into four stages—(1) *Staring* into empty space or experiencing a sensation without perceiving an object. The ability to fixate an object is lacking in the new-born because he has, as yet, no control over the muscles that move the head and eyes. The apparent looking of the first few days is not an intelligent action but only an instinctive one for the purpose of obtaining the maximum of pleasurable feeling. (2) *Looking.* The child "looks" about the end of the fifth week. By this is meant that the child turns his gaze from one bright object to another. This fixating of objects is generally accompanied by a more intelligent expression. (3) *Following.* This is closely associated with looking, but now the power to follow a bright moving object has developed. The child can control eye muscles to follow horizontal movement about the beginning of the sixth week. Vertical movements are controlled somewhat later. (4) *Observing*. This includes the active search for objects. The child has acquired the ability to direct his gaze and to hold it. This power develops between the third and the fifth month.

From the very beginning of its life a child can taste, and it is therefore necessary to see that its food is palatable, yet it may be said with truth that taste plays a comparatively small part during the first two years.

Hearing is imperfectly developed at birth ; it is probably the most imperfect of all the senses. No one has yet proved that a child can hear within three hours of birth and it is probable that for all practical purposes he is deaf until about the end of the third week. He *feels* jars rather than *hears* sounds. The slow development of hearing is partly due to the slow filling of the middle ear with air through the eustachian tube. The localisation of sounds, *i.e.* the turning of the head towards the source of the sound, develops at different times in different children ; it ranges from the tenth to the seventeenth week.

Touch develops before birth, for children born prematurely have this sense developed. The mouth and fingers are more sensitive to touch than other parts of the body, hence the child's first interest is in his mouth. The palms of the hand and the soles of the feet when touched cause clasping movements of the fingers and toes. Touch is highly educable as may be seen from the attainments of the blind.

Smell is more acute in adults than in young children. A new-born child is, however, susceptible to *strong* odours and is easily awakened out of his sleep by the smell of such substances as asafoetida and oleum dipelli. Man is inferior to the lower animals in regard to smell.

The physical activities of children are very great. During the first four years of life we get the development of such fundamental movements as sucking, grasping, mussing, kicking, experimenting in control of body and speech, creeping, climbing, walking, exploration and construction. Passive motion is enjoyed for the sake of its rhythm. The chief characteristic of infant activity is the capacity for instinctive and reflex movement. As the child develops, there is a change not merely in the number but also in the complexity, co-ordination and definiteness of the movements. The movements are often preparatory to, and correlated with, changes in the conscious states. The activities are also due partly to the need for exercise which the body develops and partly to curiosity, hence from the middle of the first year there is exhibited a tendency to pull, lift, twist and examine any object which comes within reach. Imitative play, *e.g.* as shopkeeper, engine-driver, cook, etc., figures prominently from two and a half onwards. The activities of children are signs of vitality and often of their mental development. They are means to the acquisition of knowledge and skill. These activities should not be suppressed but guided into proper channels ; as a matter of fact healthy children will be active in spite of all our attempts to subdue them.

Mental. The mental activities of children, like the physical activities, often resemble those of savages and the lower animals. But a child is not a " little savage " or a " young monkey " inasmuch as he possesses the capacity to develop into a civilised adult. The monkey and the savage state with him are merely transitory stages in his development.

Associative memory seems very weak in children at this stage. This is probably due to their small powers of attention. For most of us, our lives prior to the age of three or four are total blanks. The writer can only remember one incident in his life which can definitely be placed before the age of three. But the things of early life which are remembered seem to be remembered well, hence it would seem as if the mind is peculiarly plastic at this time, and that if the attention is riveted the memory is tenacious. But we learn by experience even if we cannot relate the experience. A baby recognises its parents, the taste of food, and pleasant or painful experiences of all kinds. " A burnt child dreads the fire " even if he cannot remember when he was burnt.

Closely connected with memory is the association of ideas. Darwin stated that " the facility with which associated ideas . . . were acquired, seemed to one by far the most strongly marked of all the distinctions between the mind of an infant, and that of the cleverest full-grown dog I ever saw." Most children resent the affront of being prepared for a walk, if the walk is not immediately undertaken. This depends upon association. Children also associate names and persons as early as the sixth month, and simple associations such as these are extremely common before the close of the first year.

Very young children undoubtedly reason but they do not reason well as judged by adults, because they have not the necessary data to form correct judgments. Tracy[1] relates "when the little boy, R., was four months old, he was playing one day on the floor surrounded by his toys. One toy rolled away beyond his reach. He seized a clothes-pin and used that as a 'rake' with which to draw the toy within reach of his hand. Mr. Darwin laid his finger on the palm of a child five months old. The child closed his fingers around it, and carried it to his mouth. When he found that he was hindered from sucking it, by his own fingers getting in the way, he loosened his grasp and took a new hold further down, then vigorously sucked the finger." The following instances[2] serve to show that children reason correctly within their limited spheres.

111. (2 yrs.). T. pulled hairs on father's wrist. Father; "Don't T., you hurt papa." T., "It didn't hurt grandpa."

112. (2 yrs. 5 mos.). M. said, "Gracie can't walk; she wears little bits of shoes; if she had mine she could walk. When I get new ones, I'm going to give her these, so she can walk."

120. (2 yrs. 9 mos.). He usually has a nap in the forenoon, but Friday he did not seem sleepy, so his mother did not put him to bed. Before long he began to say, "Bolly's sleepy; mamma put him in the crib." This he said very pleasantly at first, but, as she paid no attention to him, he said, "Bolly cry, then mamma will." And he sat on the floor and roared.

124. (3 yrs.). It was between five and six in the afternoon, the mother was getting the baby asleep. J. had no one to play with. He kept saying, "I wish R. would come home; mamma, put baby to bed, so R. will come home." I usually got home about six, and, as the baby is usually put to bed about half-past five, he associated the one with the other.

125. (3 yrs.). W. likes to play with oil paints. Two days ago my father told W. he must not touch the paints any more, for he was too small. This morning W. said: "When my papa is a very old man, and when I am a big man, and don't need any papa, then I can paint, can't I, mamma?"

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[1] Tracy: *Psychology of Childhood*; p. 63.

[2] Brown: *Thoughts and Reasonings of Children*; Ped. Sem., II., pp. 358-396, 1893. Quoted by Thorndike: *Notes on Child Study*.

128. (3 yrs.). B. climbed up into a large express waggon, and would not get out. I helped him out, and it was not a minute before he was back in the waggon. I said, "B., how are you going to get out of there now ?" He replied, "I can stay here till it gets little and then I can get out my own self."

129. (3 yrs.). G.'s aunt gave him ten cents. G. went out, but soon came back saying, "Mamma, we will be rich now." "Why so, G. ?" "Because I planted my ten cents, and we will have lots of ten cents growing."

134. (3 yrs.). F. is not allowed to go to the table to eat unless she has her face and hands washed and her hair combed. The other day she went to a lady visiting at her house, and said, "Please wash my face and hands, and comb my hair ; I am very hungry."

137. (3 yrs.). If C. is told not to touch a certain thing, that it will bite him, he always asks if it has a mouth. The other day he was examining a plant to see if it had a mouth. He was told not to break it, and he said, "Oh, it won't bite, because I can't find any mouth."

The interests of young children tend to be selfish and personal. Towards the end of babyhood the interests are so self-centred that they often lead to quarrels with their accompanying volatile emotions. The "Why ?" "What for ?" type of questioning becomes predominant. These questions do not necessarily mean that a love for scientific knowledge is being developed ; they may simply mean a general desire to extend a vague fragmentary experience. Animals often become play-fellows at this age and an interest in common objects often results in ownership, collecting and hoarding. The play interest is also strong at this period.

A child of two or three recognises the characteristic uses or functions of things. Things are the acts they suggest. Thus we get the characteristic definitions of children—"A hat is to put on the head." "A barber is good to cut my hair." "Boots are when you walk." "A cloak is warm." "Kiss is if you hug and kiss somebody." "Quarrel is if you began a little fight." "Vain is if you always look in the glass" ; and so on.

The problem of means of communication will be considered in the discussion on Language (Chap. XIX.).

But the question may be asked, "What knowledge may children be presumed to have when they begin to attend school at the age of five or six ?" In order to discover an answer, Stanley Hall carried out in September, 1880, an investigation on "The Contents of Children's Minds on Entering School."[1]

This investigation was similar to one made in the Berlin schools in 1869. Hall first made up a series of questions lying within the range of Boston children of average intelligence. To minimise the sources of error the following methods were adopted :

(1) Four trained and experienced kindergarten teachers were employed to question the children in groups of three at a time.

(2) The most honest and unembarrassed child's first answer to a direct question, *e.g.* whether it has seen a cow, sheep, etc., was not taken without careful cross-examination, *e.g.* as to the size, colour, and shape of the animal.

(3) The child was given the benefit of every doubt. The questioners were requested to report manifest gaps in the child's knowledge, *in its own words*, reproducing its syntax and pronunciation.

The following are extracts from the tables showing the general results for a number of the questions admitting of categorical answers. Table 43 is based on an average of two hundred children in Boston (a few of each type). The last two columns record the percentages obtained by Superintendent Greenwood in the schools of Kansas City. He tested 678 children of whom 47 were coloured. Hall's questions were used.

From tables 43 and 44 the following conclusions can legitimately be drawn :

> 1. That boys surpass girls in knowledge at this age (5-6). . . .
> 2. That girls excel in knowledge of the parts of the body, home, and family life.
> 3. That Irish children are backward on all the topics.
> 4. That Kindergartens are useful educational institutions.
> 5. That it is unsafe to assume the knowledge of anything of pedagogic value at the outset of school-life.
> 6. That the best preparation parents can give their children for good school training is to acquaint them with natural objects, especially with the sights and sounds of the country.
> 7. That every teacher should make some investigation into the contents of the minds of children he is called upon to teach.

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[1] Hall : *Aspects of Child Life* ; Chap. I. Reprinted from Ped. Sem., I., pp. 139-173.

TABLE 43.

Name of object of concept.	Per cent. of children ignorant of it.		
	In Boston.	In Kansas City.	
		White.	Coloured.
Beehive,	80·0	59·4	66·0
Robin,	60·5	30·6	10·6
Bee,	52·0	7·27	4·2
Growing wheat,	92·5	23·4	66·0
Elm tree,	91·5	52·4	89·8
Growing strawberries,	78·5	26·5	11·0
Location of the heart,	80·0	18·5	18·1
Location of the hips,	45·0	14·0	4·2
Right and left hand,	21·5	1·0	10·2
Dew,	78·0	39·1	70·2
Moon,	7·0	26·0	53·0
Axe,	12·0	18·4	53·0
Origin of flour,	93·4	50·8	72·3
Shape of the world,	70·3	46·0	47·0
Never been in country,	35·5	20·0	42·5
Can repeat no verse,	28·0	20·0	42·5
Origin of meat (animals),	48·0	8·3	12·7

TABLE 44.

Name of object of concept.	Per cent. of ignorance in				
	150 girls.	151 boys.	50 Irish children.	50 American children.	64 Kindergarten children.
Beehive,	81	75	86	70	61
Sheep,	67	47	62	40	40
Frog,	53	38	54	35	35
Pig,	45	27	38	26	22
Cow,	18	12	20	6	10
Growing potatoes,	55	54	62	44	34
Growing apples,	16	16	18	12	5
Ankles,	58	52	62	40	68
Elbow,	19	32	36	16	12
Cheek,	10	12	14	14	4
Hail,	75	61	84	52	53
Sunset,	47	49	52	32	29
Beach,	82	49	60	34	32
Hill,	23	22	30	12	19
Number three,	7	6	12	8	0

Such a study as this of Hall's is valuable inasmuch as it endeavours to show the end point of the mental development of the first five years of life. The great variety among different races and different individuals is clearly illustrated. The need for study of individual children, one of the most urgent of educational problems, is also emphasised. But it must ever be borne in mind that the development of an individual, both physically and mentally, is an unbroken continuity, and that division into periods is artificial.

ADOLESCENCE.

Adolescence may be usefully divided into two parts—early adolescence ranging from 11 to 18, and late adolescence ranging from 18 to 25 years of age. As the first part is more closely connected with schooling and exhibits the phenomena of the period in a more pronounced form, we shall limit our discussion to the problems connected with early adolescence.

The changes at this time, both in the mental and the physical life, are so pronounced that the period has long been regarded as the most significant in the whole of life. The church marks its inception with the sacrament of confirmation, while savages, such as the aborigines of Australia, initiate their budding adolescents into the mysteries and religious rites of the tribe. Literature also abounds with descriptions of adolescent experiences. Libby informs us that in the characters of Shakespeare there are "Seventy-four interesting adolescents among the comedies, forty-six among the tragedies, and nineteen among the histories."[1]

Physical. As the prepubertal acceleration of growth takes place some two years earlier in girls than in boys, early adolescence witnesses the phenomenon of a feminine superiority with regard both to height and weight. The following diagram helps to make this clear :

This growth in height and weight means the addition of new substance to the muscular and bony tissues. The muscles increase in length and girth and the bones to which they are attached must be strengthened to support them adequately.

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[1] Libby : *Shakespeare and Adolescence* ; Ped. Sem., 1901, 163-205.

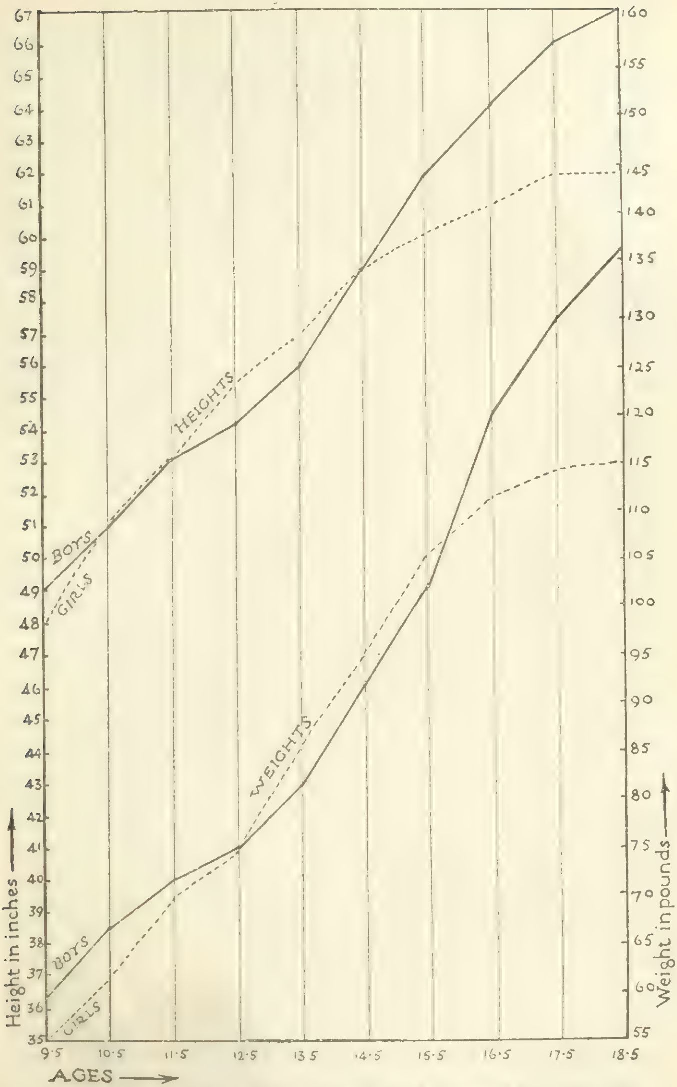

FIG. 35. Curves showing heights and weights of adolescent boys and girls.

The leg and arm bones grow both in length and thickness, the trunk elongates, the chest grows in breadth, the sacral region becomes more rigid, while the pelvis assumes the characteristic male or female form. The pelvis is enlarged in both cases, but in the female it is broadened horizontally, being inclined about 5° nearer to the horizontal than in the male. The legs grow more in the male, so that the female has a proportionately longer body. The bones of the face grow in length and breadth (except in the cases of children who breathe through the mouth, when facial development is checked), and the sutures of the skull close up. The strengthening of the bones is accomplished by the gradual ossification of the epiphysial cartilages which previously have been concerned with their increase in length. With the complete ossification at 22 to 25 years of age, the growth in the length of the bones is stopped.

The growth of the muscles brings increase of power—greater weights can be lifted and greater pressures exerted. Boys increase more rapidly than girls in this respect, although both double their gripping power between the ages of eleven and sixteen. While the efficiency of fundamental movements increases, the nicer discriminative movements lose their precision to a certain extent. For instance, the ability to discriminate between weights declines at 15 or 16, then gradually increases again. Similarly, Bryan found that the ability to place a needle in a small socket and to perform other fine movements is decreased. These facts support the view that periods of growth alternate with periods of adjustment, not merely for the body as a whole, but also for the several organs, and thus suggest that the earlier years of adolescence are important mainly for increase in size and for fundamental control ; accessory precision may develop later.

In close connection with the development of the muscular and osseous systems we find the development of primary and secondary sex characters. Boys begin to grow hair on their faces and their voices " break."

The vigorous growth of bone and muscle entails an increased food supply, hence the digestive system becomes more efficient. The absorptive surface of the alimentary canal increases in area, though not in proportion to the increased surface of the body. The jaw increases both in length and strength; this may not be merely to obtain food more easily, but may have been related in the past to the fighting instinct, since there is a great development of teeth in the anthropoid apes just before maturity.

The more rapid metabolism throws a greater strain upon the excretory system, consequently these organs tend to grow larger and stronger. There is increased secretion of the sebaceous and sweat glands. The liver and pancreas also show an increase in size and in the amounts of their secretions.

The chest grows larger and the vital capacity of the lungs increases. The greatest increase in girth is found in girls between twelve and fourteen, in boys between fourteen and fifteen, and growth is rapid to the age of eighteen. From thirteen to sixteen the natural size of the chest is the same in boys and girls, but boys have greater expansive powers. The method of breathing often changes in girls from abdominal to costal, but the change is probably artificially produced by tight clothing and could be avoided. The process of respiration is slightly different in boys and girls—less carbon-dioxide is exhaled by girls. The heart increases in size and strength. There is a greater strain put upon the circulatory system than upon the other organs, for it has to carry the augmented food supply to all parts of the body and to keep the sexual organs and the brain especially well supplied. Compared with the development of the heart, there is but little increase in the size of the blood-vessels. The tension of the arteries and the blood pressure are thus increased and these probably account for much of the excitement and exhilaration felt during adolescence.

Mental. As there is a general instability in the physical life at adolescence, so there is in the mental life also. There is a heightened mental vigour which parallels the physical growth, but whether the alternations in the emotional life are so great as Stanley Hall would have us think, is open to doubt. Probably the extremes and exceptional cases too often have been taken as the normal.

Adolescence, however, is marked by mental changes and principally in two directions: (1) a change in the *feeling-life*, and (2) a change in the *thinking-life*.

The first of these is probably the more pronounced since it is closely associated with the powerful instinct of sex.

It exhibits itself under various aspects and some of these will now be described.

There is first of all a *dissatisfaction with past achievements*. Things, interests, toys, occupations which sufficed aforetime, are now discarded as being "childish" or "only fit for babies." The same process is seen in the boy's attitude to his former self. He does not want to be a "little boy" any longer, he must be a "big chap" or better still, a man who can smoke openly and swear when and at whom he desires.[1] Silently new heroes and ideals come slipping in. The desire to be a doctor dims the once glorious prospect of being an engine-driver, and even the bold buccaneer must give place to some saint once held as poor because he apparently did so little. In all this change of feeling towards former interests and ideals, we have a dissatisfaction which is to be the foundation of future progress.

A positive aspect of the same process is the *awakening of a new curiosity*. The child becomes interested in the outer world and wants to hear of other people and other lands. He wishes to "get behind" the things he sees and handles. His own self and his own plans no longer satisfy him ; he is curious to hear of the lives of others—their fears, hopes, discoveries and sorrows. He now becomes eager to read everything he can "lay his hands on," and so great is this desire that dry ponderous tomes will be religiously read if no others are available. This curiosity often shows itself in truancy and in running away to sea, and generally in breaking the irksome bonds of social control.

The third aspect of the changed feeling-life is seen in the adolescent's *desire to express himself*, to make himself felt, to add his contribution and to "take his place in the sun." Thus the comparative selfishness of children gives way to a feeling of altruism. This feeling is not continuously present and may give way to gross forms of selfishness. But the adolescent discovers that others live beside himself and these he may seek to serve. A flood-tide of emotional life forces him to seek expression in literary effort, poetry, the keeping of a diary, or in art and music.

Permeating all the aspects of change in the feeling-life so far described, but worthy of special notice, is a change seen very clearly in the attitude to Nature, which often indeed overflows into the relationships with others and with the imagined unseen forces in the world. The change is extremely difficult to express in psychological language. Slaughter rather cumbrously describes it as a *change from the projection of images to the projection of moods.* The fact is that the adolescent ceases to regard Nature in mechanical terms and begins to think of it in terms of his own vague feelings and moods. Nature becomes something vague, mysterious, wonderful. The sea, once merely a place for bathing in or sailing upon, now becomes full of spiritual suggestions. It tells of the limitless and the infinite. Woods, stars, flowers and the moon may also take on these vague meanings.

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[1] Cf. Slaughter : *The Adolescent* ; p. 24.

This change of attitude to Nature is closely bound up with changes in religious outlook. Further, we must note that the moods of the adolescent are constantly changing. Bright optimism is succeeded by black pessimism. Especially is this the case in Protestant countries where evangelicalism is predominant. "Storm and Stress" describes the emotional life accurately. Yet "Young Indians, Turks, Chinamen or Mexicans rarely manifest the phenomenon."[1]

Finally, we have to notice a change and development in that state of feeling we call *love.* This is of course to be expected in view of the maturing of the organs of sex. The careless innocence of ignorant childhood goes and the boy begins to know he is different from the girl. Sexual thoughts more and more possess the minds of both sexes, sometimes with disastrous results. The boy, conscious of his growing manhood, becomes awkward and bashful in the presence of the opposite sex. The girl is shy, or perhaps exhibits tendencies to coquetry. "The boy suddenly begins to take an interest in his own appearance; for the first time in his life he voluntarily attends to his hair and teeth, his boots and linen; he becomes punctilious in regard to his clothing, and the choice of neck-ties is an important event. When in the company of other boys and in the presence of girls, he seeks occasions for showing his courage and strength, he willingly attacks the largest boy and incurs risk to limb in feats of skill and prowess. In the presence of the loved one he is awkward and even paralysed in expression; he never ventures to declare himself but makes use of only the vaguest hints, and often contents himself with seeing her from afar. Development in the girl is on lines similar to those observable during the mating season; she preserves an attitude of seeming indifference and is most careful not to give the attention which the boy is struggling to attract; at the same time she is seeing and understanding everything."[1]

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[1] Miss E. K. Carmen, quoted by Thorndike in *Notes on Child Study*; p. 153.

Gradually the cruder forms of sex consciousness are replaced by the more ideal aspects of kinship of mind and deep friendship. Prior to this, however, there generally comes a time, in the middle of adolescence, when the sexes withdraw from each other. The newness of sex-consciousness has gone, the delicacy of her situation dawns upon the female, and the male is busy with plans and hopes for his future career. After the period of withdrawal the sexes again desire each other's company and the consummation may be marriage.[2]

The main changes in the *thinking-life* are as follows:

First there is the *questioning attitude* which arises at this time. The adolescent begins to compare ideals and to ask why one man is better than another. He passes from mere empirical observation to an ideational and abstract world. He is unconsciously seeking for the noumena behind the phenomena; for the "ideas" of Plato behind the things seen. Virtues, for the first time, are understood in their deeper meaning. Courage, for example, is seen to be a wider thing than the daring evinced by the highwayman. The virtues of humility and sympathy, once ignored and despised as weak, are now revered as pregnant with meaning.

Arising naturally from this new movement of thought and from the increasing knowledge of the wonder and complexity of life, there comes the desire to understand the forces of Nature and to find the meaning of life. The adolescent begins to ask "why?" Hence we find the beginnings of a deep interest in science and history and of crude attempts at metaphysical thinking.

The mental attitude which indicates perplexity and asks "why?" leads on to the attitude which seeks a solution, *i.e.* to *reasoning*. The adolescent begins anew to classify, compare, accept and reject. Of course, in childhood he has reasoned, but he now turns the power to vaster subjects; he attempts, at one and the same time, to set the world and his own mental house in order. Through his new-found power he discovers flaws in the thought of the past and is often relentless in his rejection of what he feels to be untrue. Thus arises what Hall has described as

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[1] Slaughter: *The Adolescent*; p. 37.

[2] An extreme example of this withdrawal is seen in some of the western universities of America, where the freshmen absolutely refuse to attend "Sissy" (women's) courses, and separate classes have to be formed for them.

Mental Storm and Stress. This condition affects the mental life in various ways. The adolescent may discover a clash between his previous schemes of thoughts and his new experiences. There may, for example, appear to be something "unreal" about the dogmas he repeats at school prayers. Or the moods of adolescence may be challenged by new facts "To tell the moon-struck maiden that she is gazing at a globe of cold lava is a shock akin to that which the Greeks felt when told by Anytus that Socrates held the moon to be a stone."[1]

Or again the dominant aspect of the internal storm and stress may be revolt against existing conditions. This may take the form of violent reactions. Wearied by what he feels is unworthy or hypocritical, he rushes into diatribes against existing forms of government or ecclesiastical usages. Or, he may withdraw from the world and its foolish din into listless dreaming and melancholic philosophising. Or, he may leave the world in what he feels is its vanity and sin, and seek peace in some form of ascetic sanctity.[2]

Education of the Adolescent. This is primarily the problem of secondary education. At the outset we may state that the proper education for the adolescent is that which first and foremost discourages morbid and abnormal conditions. The aim of the secondary teacher should be to find occupations which will healthily employ the adolescent mind and body. Keep the adolescent busy; never allow him to have "nothing to do."

Bearing these fundamental propositions in mind we may pass on to a more detailed discussion of his education.

In the first place the teacher must give the adolescent a wise use of freedom. This, at first glance, seems incompatible with the dictum "keep him busy," but a boy free to use his time need not necessarily spend it in loafing. Freedom also permits him to define his vague impulses after social values. The adolescent hungers for companionship; the "gang" or "clan" spirit is strong within him, hence the wise teacher encourages corporate games, scout patrols, school societies and out-of-school activities of all descriptions. "Normal submission to custom and environment should be enforced," says Findlay, "but variation and even eccentricity should not be too harshly judged."

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[1] Hall: *Adolescence*; II., p. 178.

[2] Hall: *Adolescence*; II., p. 184.

Care for the health of the scholars in mind and body is of supreme importance at this critical period. In the past this has often been forgotten and minds have been ruined through premature and excessive study. The period is one when, amid conditions of vigorous growth, the body is very receptive to disease and harm. Tuberculosis, nervous disorders, hysteria, formation of bad habits, and tendencies to insanity arise at this period. The teacher must do everything to protect and strengthen the adolescent so that he may meet and overcome these dangers. Close attention must be paid to see that the scholars obtain a sufficient quantity of sleep on suitable bedding, live in fresh air, bathe frequently and wear loose hygienic clothing. There is need for differentiation between boys and girls in the choice of sports, and girls especially should not participate in games which are too vigorous. Amid all these cares, the need for wise and sympathetic instruction in sexual matters by some pure man for boys, and some motherly woman for girls (preferably the parents, or failing these, the school doctor), should never be forgotten.

Lastly, there is the vexed problem of co-education. Public opinion seems to be more and more coming round to the point of view that it is wise to educate the two sexes together. Certainly co-education is the more natural, but it must only be practised under an unceasing vigilance. "Bad cases" crop up in the best of schools and may do infinite harm if they are not detected early. The curriculum for boys and girls should vary, for the sexes have different functions to perform in later life. Further, the sexes mature at different ages and hence the rate of the progress will not be the same for both. Efficient grading will, however, obviate this difficulty. But the danger of producing "mannish" women and effeminate men by co-education is not so great as was once supposed.

The problems of the curriculum, of the personal influence of the teacher, and of the best type of schools for the adolescent are too vast to be dealt with in this brief chapter. They are, however, not neglected because we think them unimportant.

References. Baldwin: *The Story of the Mind*; Chap. IV. Baldwin: *Mental Development in the Child and Race*; 3 vols. Burnham: *Study of Adolescence*; Ped. Sem., I., p. 174. Chamberlain: *The Child*; (Extensive Bibliography). Clouston: *Adolescence*; Child Study, V., 3. Daniels: *The New Life: a study of Regeneration*; Amer. Jour. Psy., VI., 1. Drummond: *The Child*; Chap. IV. George Eliot: *The Mill on the Floss.* Hall: *Adolescence*; 2 vols. Hall: *Aspects of Child Life*; Chap. I. Hall: *Youth*; (Abridgment of Adolescence). Howells: *A Boy's Town.* James: *Varieties of Religious Experience*; Chap. I. Meredith: *Richard Feverel.* Moore: *Mental Development of a Child*; Psy. Rev. Mon. Suppl., 3, 1896. Mumford: *Dawn of Character.* Rowe: *The Physical Nature of the Child.* Preyer: *The Mind of the Child*; 2 vols. Russell: *Manchester Boys*; Chap. I. Shinn: *Biography of a Baby.* Shinn: *Notes on the Development of a Child*; Univ. of California Studies, I.-IV. Slaughter: *The Adolescent.* Sully: *Studies of Childhood.* Thorndike: *Notes on Child Study*; Chaps. XIX. and XX. Tracy: *The Psychology* of *Childhood.* Urwick: *Studies of Boy Life in our Cities.* Wilson: *Bibliography of Child Study*; Clark Univ.

SECTION VI.

CHAPTER XVIII.

EXCEPTIONAL SCHOOL CHILDREN.

Children cannot be divided into groups in which the lines of demarcation are absolutely sharp and rigid. Whenever careful measurements of any physical, mental or moral trait have been made, continuous scales have invariably been discovered. It is open to question if any human trait or capacity breaks off so sharply that we can say, "Here is a group in which all are equal." Even in such a group as the blind, where all at first glance seem to be equal, there is a hidden continuous scale. Some in reality are more blind than others, inasmuch as it would take a greater miracle of regeneration to restore their sight.

The bulk of children are normal or mediocre or average with respect to any trait. Fading away in both directions we get the exceptional children of the world—the abnormals who exhibit extreme individual differences. Some will exhibit exceptional superiority, others exceptional inferiority.

For convenience of classification we may divide these extremes of the scale into:

1. (*a*) Those who are supernormal in intellect—prodigies, precocious individuals, geniuses and brilliant children of every description.
   (*b*) Those who are subnormal in intellect—the backward children, mental defectives, imbeciles and idiots.
2. (*a*) Those who are supernormal in morals—the saints of society.
   (*b*) Those who are subnormal in morals—the

excessively cruel, deceitful, egotistical, passionate, and destructive; the moral imbeciles, thieves, rascals and knaves of all kinds.

3. (*a*) Those who are supernormal in physique—the excessively tall or heavy, and the very healthy.
   (*b*) Those who are subnormal physically—the undersized, the blind, deaf, crippled and diseased.

A discussion of all the types would lead us too far afield, although the problems of the exceptionally gifted in intellect, of the blind, and of the deaf are extremely interesting from the standpoint of Psychology. We shall, therefore, limit our discussion to the problem of the class known as the feebleminded.

Definition of Feeblemindedness. With respect to intellect, feebleminded children come between backward children on the one hand and imbeciles on the other. Since the lines of demarcation are artificial it will perhaps be advisable to define each of the grades of subnormal intellect.

(1) *Backwardness* is "a condition in which mental development is retarded through disease, sense-deprivation or some other adverse condition; if suitable treatment can be adopted the child improves and becomes mentally normal."[1]

(2) "A *feebleminded* person is one who is capable of earning a living under favourable circumstances, but is incapable, from mental defect existing from birth, or from an early age, (*a*) of competing on equal terms with his normal fellows; or (*b*) of managing himself or his affairs with ordinary prudence."

(3) "The *imbecile* is one who, by reason of mental defect existing from birth or from an early age, is incapable of earning his own living, but is capable of guarding himself against common physical dangers."

(4) "An *idiot* is one so deeply defective in mind from birth or from an early age, that he is unable to guard himself against common physical dangers."

The last three definitions were suggested by the Royal College of Physicians of London and accepted by the Royal Commission on the Care and Control of the Feebleminded.[2]

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[1] Lapage: *Feeblemindedness in Children of School Age*; p. 323.

[2] *Report*; 1908, Vol. VIII.

The definitions are in terms of economic status and of the ability to take care of the person. From the standpoint of the educator the difference is one of educability. Backwardness is eradicable by education; feeblemindedness, imbecility and idiocy persist throughout life.

Number of Feebleminded. At the time of the appointment of the Royal Commission on the Care and Control of the Feebleminded in 1904, there were no statistics available. Detailed inquiries were made in a few special districts and as a result of these the Commissioners came to the conclusion that "in England and Wales the number of mentally deficient children may be expected to be, in the areas urban and rural, ·79 per cent. of the number of children on the school registers, falling as low as ·28 in a northern colliery district, and rising as high as 1·12 and 1·24 in urban areas."[1] These percentages give us a total number of about 48,000, of whom 36,000 need educational provision. Since 1908 a national system of medical inspection has been in force and many returns on feeblemindedness have been produced. Commenting on the returns, the Chief Medical Officer in his report for 1911 (p. 194) states that "Speaking generally it would appear that medical inspection indicates that about 0·50 per cent. of children of school age throughout the country are feebleminded. This estimate does not include imbecility. On 5,400,000 children (which is approximately the number of children in average attendance in the public elementary schools) this figure would yield the total number of feebleminded children as approximately 27,000. Inquiry has shown that from one-fifth to one-seventh of such children are low grade and ineducable. Making the necessary deduction it may be said that there are some 24,000 feebleminded children for whom special provision should be made, for 12,000 of whom some provision already exists." As the above figures are based on average attendance, they do not err on the side of over-statement; they probably do not include all mentally deficient children. The following table, combined from the returns of 1910 and 1911, shows the incidence of "feebleminded" among the children of routine groups who have been examined as to their mental condition:

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[1] *Op. cit.*; pp. 192-3.

TABLE 45.

Counties.		Urban areas.	
Name of area.	Percentage.	Name of area	Percentage.
Hertfordshire, - -	2·50	Grimsby, - -	2·60
Norfolk, - - -	1·19	Huddersfield, -	2·10
Devonshire, - -	·50	Hereford, - -	1·96
East Suffolk, - -	·47	Rowley Regis, -	1·51
Lincolnshire, - -	·40	South Shields, -	·57
Oxfordshire, - -	·40	Stoke-on-Trent, -	·50
Staffordshire, - -	·40	St. Helens, - -	·37
Surrey, - - -	·40	Plymouth, - -	·34
Denbighshire, - -	·27	Bradford, - -	·31
Gloucestershire, -	·27	Manchester. - -	·31
Derbyshire, - -	·22	Tynemouth, - -	·18
Middlesex, - -	·20	Wakefield, - -	·17
Lancashire, - -	·18	Dover, - - -	·15
Durham, - - -	·10	Derby, - - -	·13

Goddard,[1] after an examination of 2,000 normal school children, estimated that 78 per cent. are practically normal, 4 per cent. are "gifted" above normal, 15 per cent. are backward, and 3 per cent. are mentally defective. This estimate, taken in conjunction with the statements that the average size of a family containing feebleminded children is seven or eight[2] (Tredgold), 6·11 in Edinburgh (Elderton and Pearson, *Memoir X. of the Eugenics Laboratory Memoirs*) 6·14 in Manchester (Lapage), and with the fact that primary feeblemindedness is hereditary, shows that the problem is one of the most pressing for civilised nations at the present time. We are recruiting our stocks from below rather than from above.

Diagnosis of Feeblemindedness. Since feebleminded children are not sharply differentiated from those of greater or less intellectual ability, their detection becomes extremely difficult. Examination reveals the fact that in some traits a feebleminded child may be superior to a normal child. There is much overlapping and distortion. The Chief Medical Officer of the Board of Education suggests that the examination should take account, among others, of the following factors:[1] (1) Family History; (2) Personal History; (3) Physical Conditions, (*a*) General—speech, sight, hearing, nose and throat, (*b*) Stigmata—general retardation (cretinoid development), cranium (microcephaly), hydrocephaly, asymmetry, rickets, imperfect closure of the fontanelles, hair, face, lower jaw, eyes (mongoloid), ears, tongue, teeth, palate (arched), fingers and limbs; (4) Mental Conditions, (*a*) reactions of motor mechanism, (*b*) reactions resulting from sensory stimulation (*c*) emotional conditions, (*d*) tests of intelligence, and (*e*) tests of will power. Finally he recommends the use of the mental tests designed by Binet and Simon as valuable aids in assessing the intelligence. Since these tests are of such great interest to students of child nature, a short account of them will now be given.

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[1] Ped. Sem., XVIII., June, 1911.

[2] A normal family contains an average of a little more than four

The Binet-Simon Tests. These tests are designed to provide a quick means for the psychological diagnosis of the grade of intelligence of children. They are more elaborate than those arranged by Sante de Sanctis of the University of Rome.[2] They aim to test the native ability uninfluenced, so far as is possible, by difference of training. The tests extend from those suitable for infants to those suitable for adults. They were first published in *L'Année Psychologique* for 1905, and have been twice revised—in 1908 and in 1911. The latest revisions can be obtained in the *Bulletin de la Société libre pour l'étude psychologique de l'enfant*, April, 1911, which also contains particulars and instructions as to the way the tests should be applied.[3]

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[1] *Annual Report for* 1911. Appendix A.

[2] See Whipple: *Manual of Mental and Physical Tests*; Chap. XIII., for a description of these tests.

[3] Translations are obtainable. For the benefit of those who desire readily available lists in English, the following references are given. Whipple's *Manual of Mental and Physical tests* gives the whole of the 1905 and 1908 series with detailed instructions on, and criticisms of, their use. The 1911 series is reprinted, in outline form only, in the *Chief Medical Officer's Report* for 1911, and in Bagley: *Recent Literature on the Binet Tests*; Jour. of Ed. Psy., III., 2, 101-109. The 1908 series, in a very convenient form, is given by Huey in the Jour. of Ed. Psy., I., 8, pp. 435-444. Terman and Childs make *A Tentative Revision and Extension of the Binet-Simon Scale of Intelligence* in the Jour. of Ed. Psy., III., 2, 3, 4 and 5, 1912. Goddard, in two valuable articles, *The Binet and Simon tests of in-*

Binet and Simon give two rules for the tests: (1) A child has the intelligence of that age for which he succeeds in passing all the tests; (2) After fixing the age for which a child passes all the tests, a year is added to the intelligence age if he has succeeded in passing five additional tests belonging to superior age groups, two years are added if he has passed ten such tests, three years if he has passed fifteen, and so on. A third rule formulated by Goddard states that (3) If a child can only succeed in passing those given for three years younger than himself, he is mentally defective.

The extensive use of these tests in practically every civilised country during the past six years has led to much pointed criticism and many suggested modifications. Kirkpatrick[1] warns us that "the determination of whether a person is normal, retarded or accelerated in his mental development is not a test of mental ability in the sense of indicating how successful he will ultimately be in any line of intellectual effort, but is only an indication that the mode of intellectual activity is of the more or less mature type." "If by general mental ability is meant something analogous to a test of strength or skill, I do not believe that the Binet tests, or any other tests likely to be devised within the century will serve as a reliable measure." Decroly and Degand, and Terman and Childs find that the tests at the lower end of the scale are too simple and those at the upper end too difficult for the assigned year. Other tests are too mechanical and some depend too much on training.

Terman and Childs,[2] in their tentative revision and extension of the tests, frankly discard many of Binet's and insert others in their places. Although those inserted take up considerable time, they seem to the writer to be very valuable. The following list of tests is based upon that of Terman and Childs. Minor alterations have been made to suit English conditions, and the whole is given in

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tellectual Capacity, The Training School, V., 3-9, Dec., 1908, and *A Measuring Scale for Intelligence*, The Training School, VI., pp. 146, 155, Jan., 1910, gives the results of the extensive application of these tests.

[1] *Communication*; Jour. of Ed. Psy., III., 6, p. 337.

[2] *Jour. of Ed. Psy.*, III., 2, 3, 4, 5, 1912.

greater detail. The reference, in brackets, at the end of each test indicates its origin.

REVISED BINET-SIMON SCALE.

YEARS I. AND II.

1. Eye follows a lighted match moved slowly before the face, or subject adopts a listening attitude when bell is rung behind him. (1905, 1.)

2. A wooden cube is grasped and handled when placed in the palm. (1905, 2.)

3. Suspended spool or cube is grasped when seen. (1905, 3.)

4. Chocolate or candy is chosen in preference to a piece of wood of similar dimensions. (1905, 4.)

5. Paper is removed from chocolate before eating, child having seen it wrapped up. (1905, 5.)

6. Child obeys simple commands, and imitates simple movements.

For example, (*a*) shake hands ; (*b*) be seated ; (*c*) pick up the box ; (*d*) go to that chair ; (*e*) come back ; (*f*) "do as I do" then clasp hands ; put hands on the shoulders ; place hands behind back ; rise on toes, etc. (1905, 6.)

YEAR III.

1. Replies to problem questions.

(*a*) "What's the thing to do when you feel sleepy ?"
(*b*) "What's the thing to do when you feel cold ?" (1905, 27.) (Both must be passed.)

2. Discriminates between weights. "Here are two little boxes : which do you think is heavier ?"

(*a*) 3 grams and 12 grams ; (*b*) 6 and 15 ; (*c*) 3 and 12. (1905, 12 ; 1908, 10.) (Two out of three.)

3. Names familiar objects correctly.

(*a*) a key ; (*b*) a closed penknife ; (*c*) a penny. (1908, 7.) (No failure.)

4. Knows sex. "Are you a little boy or a little girl ?" (1908, 6.)

5. Repeats three digits in order, when heard once.

(*a*) 641 ; (*b*) 352 ; (*c*) 783. (1905, 11 ; 1908, 8.) (Two successes.)

6. Enumerates three familiar objects in pictures, *e.g.* a man, a dog, and a knife. (1905, 9 ; 1908, 4.) (No failures.)

YEAR IV.

1. Copies a square so that it can be recognised. (1908, 11.)

2. Counts four pennies correctly when they are placed in full view before him. (1908, 13.)

3. Rearranges a rectangular card, 8 × 14 cm., which has been cut diagonally into two triangles. (1908, 12.)

4. Chooses the pretty rather than the ugly and deformed faces in pictures. Two faces are presented at a time and the question is asked, "Which of these two is the prettier?" (1908, 16.) (No failures.)

5. Defines, in terms of use, the words table, chair, horse, and mamma. (1905, 14; 1908, 17.) (Three out of four correct.)

YEAR V.

1. Knows whether it is the morning or afternoon. (1908, 20.)

2. Names colours, red, yellow, blue and green. Coloured rectangle is touched and question, "What colour is that?" is asked. (1908, 31.) (No failure.)

3. Executes a triple order correctly. "First put the key on the chair, then close the door, then bring the box." (1905, 6; 1908, 18.)

4. Vocabulary index is found by finding out how many words are known out of 100 chosen, by taking the last word of every sixth column of a dictionary with 18,000 words. (Terman test: Jour. of Ed. Psy., III., 4, p. 205.) (Score ?)

5. Repeats easy sentences of thirteen to sixteen syllables.
   (*a*) "We expect to have a great time down at the seashore."
   (*b*) "When the train passes, the engineer will blow the whistle."
   (*c*) "Why should anyone want to harm a beautiful bird?" (1908, 16.) (One success out of three.)

YEAR VI.

1. Knows the difference between the left and right. "Show me your right hand." "Show me your left ear." (1908, 14.)

2. Knows the number of fingers on right hand, left hand, both hands, without counting. (1908, 22.)

3. Counts thirteen pennies placed in a row. (1908, 27.)

4. Repeats 4 digits in order, when heard once.
   (*a*) 4739; (*b*) 2854; (*c*) 7261. (Binet modified test.) (Two out of three.)

5. Replies to problem questions.
   (*a*) "What's the thing to do if it's raining when you start for school ?"
   (*b*) "What's the thing to do if you have missed a train ?"
   (*c*) "What's the thing to do if you find that your house is on fire ?" (1905, 27.) (Two out of three.)

6. Vocabulary index 12 per cent. (2160 words).

YEAR VII.

1. Copies a diamond so that it can be recognised. (1908, 24.)

2. Notes the omission of eyes, nose, mouth, or arms from 4 unfinished pictures. (1908, 21.) (Three out of four.)

3. Names four common coins—half-penny, penny, sixpence, and shilling. (1908, 28.) (No failure.)

4. Describes the pictures shown in No. 6 of year three as a scene and does not merely enumerate the individual features. (1908, 26.) (Two out of three.)

5. Vocabulary index 14 per cent. (2520 words). (Terman test.)

6. Repeats sentences 14 to 17 syllables.
   (*a*) "We will go out for a long walk. Please give me that pretty straw hat."
   (*b*) "We are having a fine time. We found a mouse in the trap."
   (*c*) "Brother Frank had a fine time on his holiday. He went fishing every day." (1908, 15.) (One out of three.)

YEAR VIII.

1. Writes with pen and ink from dictation, "The pretty little girls," so that it can be read. (1908, 33.)

2. States differences between paper and cloth, butterfly and fly, wood and glass, in two minutes. "Do you know what paper is ? Do you know what cloth is ? Then tell me the difference between them." (1905, 16 ; 1908, 34.) (Two out of three.)

3. Counts from 20 to 0 in 20 seconds, with not more than one error. (1908, 32.)

4. Ball and field test. A circle of about 3 inches in diameter is drawn, leaving a small gap which is called a gate. The circle represents a field (covered with grass 6 inches high so that ground can only be seen ten feet on each side), in which a ball is lost. The subject is then asked to take a pencil and mark out a path showing in what direction he would walk in

hunting for the ball. Score 1 is given when field is filled with random or broken marks; 2, for lines not parallel but seldom broken or crossed; 3, for lines uncrossed and unbroken and almost perfectly parallel; 4, for lines which showed the fact that 10 feet could be seen on either side. (Score for eight year old is 2.) (Terman; Jour. of Ed. Psy., III., 4, p. 202.)

5. Repeats 5 digits in order, when pronounced at half-second intervals: (*a*) 31759; (*b*) 42385; (*c*) 98176. (1905, 19; 1908, 25.) (Two out of three.)

6. Vocabulary index 18 per cent. (3240 words). (Terman test.)

YEAR IX.

1. Counts the value of six stamps, three half-penny and three penny ones, in less than 15 seconds. (1908, 30.)

2. Names the day and date. The test is passed if the day of the month is given to within three days. (1908, 35.)

3. Repeats four facts from a passage of easy prose which is read to him. The time taken is recorded. (1908, 39.)

4. Arranges, in order of weight, boxes of the same size and appearance weighing 6, 9, 12, 15 and 18 grams respectively, in not over 3 min. per trial. (1905, 22; 1908, 40.) (Two out of three.)

5. Names at least 50 words in two minutes. (1908, 47, modified.)

6. Replies to problem questions:

(*a*) "What's the thing to do when you have been struck by a playmate who did not do it purposely?"

(*b*) "What's the thing to do when you have broken something which does not belong to you?"

(*c*) "What's the thing to do when you have been detained so that you are in danger of being late for school?" (1905, 27; 1908, 44.)

7. The child fills in the completion test blank for 15 minutes (Terman: Jour. of Ed. Psy., III., 4, p. 199) and marks are given for thought shown. A maximum of 100 is possible. Nine-year-olds make a median score of 18·4 (P.E. 8·5) and two-thirds reach the 14·9 standard. (Terman test.)

YEAR X.

1. Copies two designs cut in a quarto-folded paper. (1905, 29; 1911, 36.)

2. Uses three words in one sentence (girl, river, ball). (1905, 26; 1908, 43.)

3. Repeats six digits in order, when pronounced at half-second intervals.

(*a*) 374859; (*b*) 825746; (*c*) 762953. (1905, 19; 1908, 25.) (Two out of three correct.)

4. Obtains a score of 3 in the "ball and field" test. (Terman; see above.)

5. Vocabulary index 26 per cent. (4680 words). (Terman test.)

6. Four fables (1) "The Milkmaid and her Plans"; (2) "Hercules and the Waggoner"; (3) "The Fox and the Crow"; (4) "The Stork and the Cranes" are read slowly to the subject and after each he is instructed to write the lesson which he thinks it is meant to teach. Scoring ranges from 5 for a completely generalised and entirely relevant reply to 0 for no response, or an entirely irrelevant concrete statement. By allowing 5 credits for each unit in the score the results are stated in percentages. A normal ten-year-old makes a median score of 45, and two-thirds reach 35-40. (Terman: Jour. of Ed. Psy., III., 3, pp. 133-143.)

7. Makes a score of 20 in the completion test. (Terman test.)

8. Makes change from one shilling for an article costing 2½d. (Child has a box with 1 half-crown, 1 two-shilling piece, 2 shillings, 2 sixpences, 5 pennies and 3 half-pennies.) (1908, 37, modified.)

Year XI.

1. Arithmetical reasoning (score ?). (Use the following problems. The child is given the problems in the following form, and is asked to write the answer after each problem without making any other figures.)

(*a*) If three-quarters of a gallon of oil costs 9d., what will 7 gallons cost ?

(*b*) At 1s. a yard, how much will 7 feet of cloth cost ?

(*c*) A man whose salary is £1 a week spends 14s. each week. In how many weeks can he save 300 shillings ?

(*d*) How many pencils can you buy for 7½d. at the rate of 2 for 5d. ?

(*e*) A man spent two-thirds of his money and has 8s. left. How much had he at first ? (Bonser: *Reasoning Ability of Children in the Fourth, Fifth and Sixth Grades,* p. 2 (modified).)

2. Replies to problem questions :

(*a*) "What ought you to do before taking part in an important affair ?"

(*b*) "What ought you to say if some one asks your opinion about a person you only know a little ?"

(*c*) "Why ought we to judge a person more by his acts than by his words ?"

(*d*) "Why do we excuse a wrong act committed in anger more readily than a wrong act committed without anger ?" (1905, 27; 1908, 44.) (Three out of four correct.)

3. Vocabulary index 30 per cent. (5400 words). (Terman test.)

4. Fable test (*supra*).

An eleven-year-old normally makes a median score of 50-55, and two-thirds reach 45-50. (Terman test.)

5. Makes a score of 25 in the completion test. (Terman test.)

6. Sees the point in the following samples of wit and humour. Experimenter reads each passage and asks subject, "What is the point of that joke ?" "What is funny about that ?" etc.

(*a*) A man called at the post-office to inquire if there was a letter for him. "What is your name ?" said the postmaster. "Sure," said the man, "you'll find my name *on the back of the letter*."

(*b*) A woman was once told of a man who had twice had smallpox and had died of it. "Did he die the first time or the second ?" the woman asked.

(*c*) A young fellow who wanted to be witty once said to a barber, "Did you ever shave a monkey ?" "Why, no, Sir," said the barber; "But if you will please sit down I will try."

(*d*) A religious old lady used to say that God was very good to make the greatest rivers flow past the largest cities.

(*e*) A pedlar in his cart overtook another pedlar on the road and thus addressed him, "Hello, what do you carry ?" "Drugs and medicines," the other replied. "Go ahead, then," said the first; "I carry gravestones." (1908, 45, modified.) (Three out of five satisfactory.)

YEAR XII.

1. Detects the incongruities or absurdities in the following in about 2 minutes :

(*a*) "An unfortunate bicycle rider broke his head from a fall and died instantly. He was picked up and carried to a hospital, and they do not think he will recover."

(*b*) "I have three brothers—Paul, Ernest and myself."

(*c*) "There was a railroad accident yesterday, but it was not serious. The number of dead is only 48."

(*d*) "We met a man who was finely dressed: he was walking along the street with his hands in his pockets and twirling his cane."

(*e*) "The engineer said that the more carriages he had on his train the faster he could go."
(1908, 45, modified.) (Four out of five correct.)

2. Rearranges the shuffled words of 3 sentences in less than a minute for each.

(*a*) "a defends
dog good his
master courageously."

(*b*) "my have teacher
I the correct
asked paper to."

(*c*) "home our early
we country in left
visit the to friends." (1908, 49.) (All correct.)

3. Repeats seven facts from a passage of easy prose which is read to him. The time taken is recorded. (1908, 39.)

4. Degree of suggestibility is found. (1911 series, No. 40.)

5. Vocabulary index 36 per cent. (6480 words). (Terman test.)

6. Repeats, with no error, sentences of twenty-six syllables.

(*a*) "My little children, you must work very hard for a living. You must go every morning to your school."

(*b*) "The other day I saw in the street a pretty yellow dog. Little Bessie has spots on her new apron."

(*c*) "Ernest is often punished for his bad conduct. I bought at the store a pretty doll for my little sister." (1908, 52.) (One out of three correct.)

YEAR XIII.

1. Repeats seven digits in order, when pronounced at half-second intervals: (*a*) 2183439; (*b*) 9728475; (*c*) 3247196. (1908, 50.) (Two out of three correct.)

2. Vocabulary index 42 per cent. (7560 words). (Terman test.)

3. Fable test (*supra*).

An eleven-year-old normally makes a median score of 70, and two-thirds reach 55-60. (Terman test.)

4. Arithmetical reasoning (score ?). (See above, Bonser test.)

5. Makes a score of 36 in the completion test. (Terman test.)

6. Answers the following problems of fact :

   (*a*) My neighbour has been having queer visitors—first a doctor, then a lawyer, then a priest. What's happening at my neighbour's ? "

   (*b*) An Indian coming to town for the first time watched a white man riding along the street. As the white man rode by, the Indian said, " White man lazy : him walk sitting down." What was the white man sitting on ?

   (*c*) A man who was walking in the woods near a city stopped suddenly, very much frightened, and ran to the nearest policeman, saying that he had just seen hanging from the branch of a tree, a——. (1908, 53.)

YEAR XV.

1. Fable test (*supra*) (score ?).

2. Changes hands of a clock (4 minutes to 3 o'clock). (Must be able to recognise the slight discrepancy.) (1905, 28.)

3. Interprets pictures which are shown to him, that is, he makes up a story which " fits " the picture. " Tell me what that is about." (1905, 9 ; 1908, 4.) (Two out of three.)

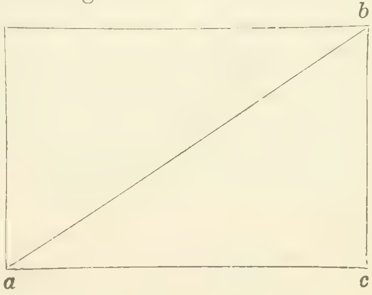
4. Vocabulary index (score ?).

5. Completion test (score ?).

6. Uses code (see Goddard's Article, *The Training School*, May, 1911.)

ADULT.

1. Can solve the reversed triangle test. " Present a large visiting card cut in two along *ab*. Suppose we turn over the lower triangle so that *c* (point) should lie at *b* (touch) and *ac* should lie along *ab* (touch). Remove the lower piece and have the subject image and draw the new total shape suggested, beginning with the upper piece." (1908, 55.)



2. President and King (see Goddard's article cited above).
3. Obtains a score of 4, with the conditions stated, in the ball and field test. (Terman test.)
4. Completion test (score ?). (Terman test.)
5. Gives the sense of the following selection :

> "One hears very different judgments about the value of life. Some say it is good, others say it is bad. It would be more correct to say that it is mediocre, because, on the one hand, it brings us less happiness than we want, while, on the other hand, the misfortunes it brings are less than others wish for us. It is the mediocrity of life that makes it endurable, or, still more, that keeps it from being positively unjust."

A standardised series of *Mental Tests for Backward and Defective Children*, which freely uses the Binet-Simon tests, has recently been arranged by W. H. Winch.[1] The schedule seems convenient, but no indication is given as to what standard of success in the tests should be used to differentiate normal, backward and mentally defective children.

Characteristics of the Feebleminded. Feebleminded children often show the physical stigmata of degeneration —defects in the size and shape of the head, deformities of the external ear, deformities connected with eyes, palate and jaws—but these are not invariably present and normal children may exhibit them also. They tend to be slightly undersized (Lapage), and Norsworthy found that their body temperature was below normal. This latter defect may have an important bearing on their mental capacity.

With regard to mental characteristics, the feebleminded exhibit a general sluggishness, lack of sensitiveness, and general inability to retain impressions. Hazarding a description of the exceptionally unintellectual, Thorndike[2] states, "They are weak in the number, delicacy, complexity, speed of formation, and permanence of associations of whatever sort, especially so when one or both of the members to be connected is an idea. They are weaker in the analysis or abstraction of elements out of gross total situations, and the determination of thought by the action of a part or element or aspect of a situation. They are as a result weakest in those functions which require the co-operation of many selected associations and the partial activity of many relics of past experiences in the service of some complex and ideal situation or problem. They are also usually very weak in the instinct of mental activity, in the satisfaction of mental life for its own sake. They represent the extremes of condition found in stupid people generally, the opposite of the gifted person who connects rapidly, precisely and permanently, analyses facts into their elements easily and often, thinks facts together, is guided by remote and ideal ends, and enjoys thinking for its own sake.

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[1] Published by Ralph Holland and Co., 1913.

[2] *Educational Psychology*; 2nd ed., p. 219.

"They are inferior in sensitivity, but their appearance of being very much so is due in part to their willingness to live in mental torpor, their failure to connect sense impressions with anything further, and their more frequent failure to analyse out colour, size, shape and the like from the gross total situations whose partial aspects they are.

"They are inferior in movement, but their appearance of very great inferiority in it is due in part to their failure to connect movements with percepts and ideas or to analyse out and get control over portions of movement-series and recombine them anew. They are very inferior in attentiveness from the point of view of one to whom attentiveness means power of attention to elements rather than to gross totals, intellectually fruitful things rather than the natural objects of the instincts connected with food, fears, sex and the like, or past and future situations rather than present situations. But the words, 'lack of power of attention' do not properly explain but only name this fact. The facts given above are again the real explanation. To this characterization there are numerous exceptions."

The Education of the Feebleminded. Remembering that the feebleminded are chronically immature, we must adapt the curriculum to their stages of development. The teacher should strive to establish useful habits of all descriptions, chiefly by making the rewards or satisfaction immediately follow any desirable act. He should aim to fix important facts by rich and varied associations, rather than by repetitions of a single association, and make use of attention by mainly treating of facts of vital interest to them. Lastly, since they enjoy doing things which lie within their powers, and since "booky" tasks are denied them, they should be given tasks of an extremely practical nature. All types of manual training are invaluable in this connection.

References. Bagley: *Recent Literature on the Binet Tests*; Jour. Ed. Psy., III., 2, pp. 101-109. [Reviews the following: Binet and Simon: *Le développement de l'intelligence chez les enfants*; Année Psychologique, 14, 1908, 1-94. Decroly and Degand: *La mesure de l'intelligence chez des enfants normaux d'apres les tests de MM. Binet et Simon*; Archives de Psychologie, 9, 34, 81-108, 1910. Binet: *Nouvelles recherches sur la mesure du niveau intellectuel chez les enfants d'école*; Année Psychologique, 17, 1911, 145-201. Binet and Simon: *La mesure du développement de l'intelligence chez les jeunes enfants*; Bull. d. e. Société Libre pour l'étude Psy. d. l'Enfant, 70 and 71, 187-248, 1911. Goddard: *Two Thousand Children measured by the Binet Measuring Scale of Intelligence*; Ped. Sem., 18, 232-259, 1911. Bobertag: *Ueber Intelligenzprüfungen* (*nach der Methode von Binet und Simon*); Zeit. f. Angewandte Psychol., V., 2, 105-203, 1911. Johnston: *Binet's Method for the Measurement of Intelligence—Some Results*; Jour. Exper. Ped. and Training College Record, I., 1, 24-31, 1911. Descœudres: *Les tests de Binet et Simon et leur valeur scolaire*; Archives de Psychologie, XI., 44, 331-350, 1911. Lawrence: *A Study of the Binet Definition tests*; Psy. Clinic, V., 7, 207-216, 1911. Ayres: *The Binet-Simon Measuring Scale for Intelligence*; *Some Criticisms and Suggestions*; Psy. Clinic. V, 6, 187-196, 1911. Terman: *The Binet-Simon Scale for Measuring Intelligence Impressions gained by its Application on Four Hundred Non-selected Children*; Psy. Clinic, V., 7, 199-206, 1911. Huey: *Backward and Feeble-minded Children. Clinical studies in the Psychology of Defectives, with a Syllabus for the Clinical Examination and testing of Children*; 189-202, 1912.] Board of Education: *Annual Reports of Chief Medical Officer*, 1908 to date. Ellis: *Man and Woman.* Johnson: *Contributions to the Psychology and Pedagogy of Feeble-minded Children*; Ped. Sem., III., 246-301. Kuhlmann: *Experimental Studies in Mental Deficiency*; Amer. Jour. Psy., XV., 391-4. Lapage: *Feeblemindedness in Children of School Age* (contains an excellent Bibliography). Norsworthy: *The Psychology of Mentally De-*

ficient Children. Potts: *The Recognition and Training of Congenital Mental Defectives*; Brit. Med. Jour., May 9th, 1908. *Report of the Royal Commission on the Care and Control of the Feebleminded*; 8 vols., 1908. Thorndike: *Educational Psychology*; 2nd ed., Chap. XI.

SECTION VII.

THE PSYCHOLOGY OF A SPECIAL SUBJECT.

CHAPTER XIX.

THE DEVELOPMENT OF LANGUAGE IN CHILDREN.

In connection with the development of language in children there are three main problems. The first of these is concerned with the understanding and use of the mother tongue. The second centres around Reading—the understanding of written and printed symbols. The third problem involves both Writing and Spelling, since it is concerned with the development of the ability to use the vernacular in writing.

Language an Inherited Capacity. The power to use some form of language is innate in every human being. Even the deaf-mute has a language, for he communicates with his fellows by means of a sign or gesture language. This capacity for language is, however, not perfect at birth ; it is one of slow development, depending as it does upon the maturing of the vocal organs and of the general intellectual powers, as well as upon the various environmental stimuli.

But we must not fall into the error of thinking that it is the ability to use a specific language, such as French, English or German, which is inherited. We inherit a capacity for *language* not for *a language*, and the particular direction the development takes is dependent upon environment. An English child reared in a French speaking family from infancy will have French for its mother tongue, while English will be considered a "foreign" language.

In connection with the question of language as an inherent capacity, the story told of Psammetichus, King of Egypt (d. 610 B.C.) by Herodotus is of interest. This monarch wishing to discover which was the original language of the world, placed two children under the care of a shepherd and instructed him not to utter a sound in their presence and to keep them from all human associations. The first word they uttered was *bekos* which is the Phrygian word for bread and hence Psammetichus concluded that Phrygian was the parent language. The story is probably untrue for the children would have developed a sign language in imitation of the shepherd's, and even if it is true, the word stripped of its Greek ending can be interpreted as an onomatopœic rendering of the bleating of the shepherd's goats.

Value of Language. Language is *par excellence* the tool of thought. All ideal representation, and conceptual analysis and synthesis are based upon it. Language fixes the attention upon universals in contradistinction to particulars, for it is the universals which give meanings to words.

Moreover language aids memory, for the mere fact of naming is an invaluable help to retention.[1]

Language is also the medium of social heredity. Oral language annihilates space, for it enables us to project our ideas outwards and to break down the barriers existing between mind and mind. Written language enables us to annihilate both space and time. Thus, to-day, we are able to enjoy the thoughts that passed through the minds of Plato and Aristotle more than two thousand years ago. In the early history of mankind transmission was imperfect and unreliable, but with the invention of writing, the accuracy of the records was immeasurably increased. Take away this social inheritance and civilisation is destroyed, nay, further, existence itself becomes impossible.

Function of Language. The function of language is usually declared to be the *expression of thoughts and feelings.* The inadequacy of such a definition has been pointed out by Thorndike,[2] who has shown that language is also used to *arouse* thoughts, feelings and movements. When we say, "Shut the door," we do not express our feelings or thoughts, or, at least, only imperfectly. Communication is not the primary object; we want to arouse or stimulate a certain action in others. When the physician says "Open your mouth," we do not think "Physician wants *me* to open *my* mouth"; we simply open it at once.

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[1] Judd: *Psychology*; p. 261.

[2] In an unpublished lecture, 1909.

Linguistic Development in Children. All language apparently has developed from the natural cries—shouts, groans, hisses and grunts—of mankind. The first stage of development was when these cries evolved into interjections of the oh! hush! no! variety. Into these interjectional elements a variety of tones was introduced. These become definite and fixed, and at last the sounds become articulate.

The ability to understand language is always ahead of the ability to use it both in the race and in the individual. This statement can be proved for the individual by a careful study of language development in a child during the first three years of life. The best method of carrying out such a study is to live with the child and make a careful list of all the words he uses, noting the dates of first appearances. Failing this, a stenographic record of the complete vocabulary a child uses during a particular day may be made. If the record is repeated at intervals of a week or a month, a fairly accurate picture of the increasing command over language may be obtained, although the method is not so accurate as the preceding one.[1]

All children exhibit a pre-linguistic stage during the first eight months, or thereabouts, of life. The cries of the first month are almost undifferentiated, although careful nurses and mothers can distinguish the cry of pain from that of hunger, and even in some cases between the cries representing different degrees of discomfort. The first sounds are *ă* or *uä*. The easiest consonants are the labials *m*, *p* and *d*. These become attached to the primordial vowel and we get such words as mama, dada, papa, etc. Since the otherwise meaningless sound mama is the first to bear any resemblance to ordinary speech, the mothers of practically all nations have appropriated this word as a pet name for themselves.

The first responses of children are not to words as such, but to different gestures, intonations, grimaces and pantomime. The truth of this is seen when the statement "Ah! you are a naughty baby!" is made with a smiling face and a calm voice to a baby. The baby's response is a chortling laugh. But tell the baby that he is a sweet little angel in a gruff voice and the result is a terrified "squall."

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[1] See O'Shea: *Linguistic Development and Education*: a valuable monograph on language development. The writer acknowledges his indebtedness for much of the information contained in this section.

It is very probable that words, especially at first, are not heard at all, or only imperfectly. The process may be compared to the perception of a foreign language when it is first heard. The whole thing seems, in the words of James, to be just "one great blooming, buzzing confusion," out of which the separate words emerge only after many experiences of them. And many observers maintain that in listening to a speech in the mother tongue, we do not hear the whole of the sounds made. We perceive vague "slurred" sounds and fill in the meanings from past experiences (cf. Chap. XIV.).

In the use of language the meaning is filled out with gestures and intonations. In some of the children's "sentence-words," the intonations and gestures are the sole keys to the meaning. Thus "Mama" may mean "Please, Mama take me up and carry me," or "Please Mama give me some more food," etc., according to the way in which it is pronounced. In Chinese the inflection gives the meaning; the same written form may have several different meanings. Pronounced with a rising inflection the word has one meaning; pronounced with a falling inflection it takes on another.

Since language is wholly concerned with the conveyance of ideas from mind to mind, the unit of language must everywhere be the sentence. When a single word is used, it has the force of a sentence and many persons return to a similar stage when giving commands. "Hat" or "Hat please," said to a waiter means, "Please reach me my hat." And the Chairman of the Company in Galsworthy's *Strife* is a classic illustration of few words carrying much meaning. In early life the interjectional or explosive element in language is strong, although the actual interjectional forms develop fairly late. The interjectional element in adolescent slang is much too forcible to be passed unnoticed by even the most casual of observers.

The adjectival function can be traced from the age of one and a half years onwards. Adjectives are usually attached to names of food which may be cold, hot, good, nasty, sweet or nice. In some cases the adjective has no real meaning. A "nice dolly" may simply be a "dolly."

Somewhat later, the adverbial function develops. "Here" is the first to appear, but it is closely followed by "where." After asking a young boy if he had been to various places which I named, I got the unexpected reply, "I've been to lots of wheres," and this effectually stopped any further questioning.

The prepositional and conjunctional functions are almost exclusively expressed by gesture at first. O'Shea records the case of "My-go-snow" standing for "I want to go out in the snow."

The pronouns are sources of trouble to every child. The confusion arises because so many of them may refer to the same individual, *e.g.* I, he, him, his, you and your may all refer to one boy. Hence there is a tendency to use the nominative form of a noun instead of the pronoun, *e.g.* "Mama give John" instead of "Mama give me." The personal pronouns I, my, mine and me are seldom used before the end of the second year, and the correct use of them is seldom found before middle school-life.

Inflections are also difficult. The adult who did not use regular plurals such as "mouses," "gooses," "tooths," and "mans" at the beginnings of his language learning, does not exist. The verb inflections are also confusing. "Buyed," "runned," and "flied" are frequently heard, and one small girl was known habitually to use "dig," "dag," "dug" as the principal parts of the verb to dig. Can and may, could and might, who and whom, are often wrongly used until comparatively late in life. The first inflected forms to appear are the comparative and superlative forms of adjectives.

The correct uses of agreement in speech are late in development. "I runs"; "He don't do right"; "The teacher with all her pupils were on the playground"; "Neither I nor you were there"; "It's me"; and "Me, Sir," are common errors of this type. In "It's me," the grammatical form seems opposed to the psychological feeling; the French form *c'est moi* or the German *Ich bin es* both seem more reasonable in this respect. As a general rule concrete words are learned and used before abstract; and words with a positive content before those with a negative content. The learning chiefly takes place by the process of trial and error. The child "plays" with words and successful forms are rewarded through the satisfaction of being understood and by evoking responses.

Range and Vocabulary. Many wild statements have been made about the range of the vocabularies of children and uneducated peasants. Laurie[1] stated that "In the child up to the eighth year the range of language is very small; he probably confines himself to not more than 150 words." A peasant is generally supposed to have a working vocabulary of 500 to 1,000 words (the philological terms). Many children of much less than eight years have had recorded vocabularies of upwards of a thousand words. Salisbury[2] found that his boy, when 5½ years of age, had a vocabulary of 1,528 "understandingly used" words, not counting participles and inflected forms (except pronouns).

Holden[3] estimated his own vocabulary at 33,456 and thought that 30,000 was not at all an unusual vocabulary. "For comparative purposes he estimated the vocabulary of Shakespeare (minus all verbs spelled like nouns), from Mrs. Clarke's *Concordance*, to amount to 24,000 words; Milton's from Cleveland's *Concordance*, for the poems alone (the prose would give a larger number), 17,377; the English Bible, from Cruden's *Concordance*, 7,209 (exclusive of proper names; Bosworth's *Dictionary of the Anglo-Saxon Language* (which contains "few words not in full use before 1100 A.D."), 11,913; *Hotten's Dictionary of Slang*, 10,000."[4]

Judging from these facts, we may reasonably expect a child on leaving school to know the meanings of 10,000-15,000 words, and of these he ought to be able to use one-quarter to one-third in speech and writing.

But we must not forget that a vocabulary is always in the making. It contains elements perfectly well known, others known but fairly well, and some which are scarcely known at all and which will disappear if no opportunity for exercise with them is afforded.

Parts of Speech. Several investigators have endeavoured to trace the varied use of the several parts of speech at different ages. Tracy[1] collected the results of several investigators who reported the vocabularies of twelve children from nineteen to thirty months of age. Salisbury[2] obtained the distribution of the parts of speech at two different ages. Miss Wolff[3] analysed the contents of a voluntarily made boy's dictionary into grammatical groups. And Kirkpatrick analysed the language of adults as given in a standard dictionary, as well as that of *Robinson Crusoe.*

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[1] Laurie: *Language and the Linguistic Method.*

[2] Salisbury: *A Child's vocabulary*; Educ. Rev., VII., (1894), pp. 287-290, cf. Binet tests.

[3] Holden: *On the number of words used in Speaking and Writing*; Bull. Phil. Soc., Washington, II. (1874-78), App. I., pp. 16-21.

[4] Holden: *op. cit.* Quoted by Chamberlain: *The Child: A Study in the Evolution of Man*; p. 160.

Table 46 gives a summary, in percentages, of the various investigations.

TABLE 46.

Investigator.	Total words.	Age.	Nouns.	Verbs.	Adj.	Adv.	Pron.	Prep.	Con.	Interj.
Tracy -	5400 12 subjects.	19–30 months.	60	20	9	5	2	2	0·3	1·7
Wolff, -	..	..	42	30	8	10	4	..	6	..
Salisbury,	642	32 months.	54·5	23·3	9·4	4·9	3·6	3·1	·6	·6
,,	1528	5½ yrs.	57·9	21·1	15·3	2·6	1·5	1·3	0·3	..
Kirkpatrick,	Dictionary	adult.	60	11	22	5·5	..	..	1·5	..
,,	Robinson Crusoe.	,,	45	24	..	..	31	..	..	..

The Teaching of Language. Language is probably more badly taught than any other branch of the elementary school curriculum. Instead of being considered as the imitative use of a tool, as it largely is in its early stages, it is taught as a science. Language is not a science since it has no principles, and only in its higher stages can it be looked upon as a fine art. The problem of treating it as an art is that of constantly reproducing living thought from its symbolic remains. Language in itself is not highly educative; its value as a study comes from the experiences of life which it symbolises and from its pre-eminently social nature. It should only be used in school when it has definite advantages over other forms of expression.

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[1] Tracy: *Psychology of Childhood*; Chap. V., 1901.

[2] Salisbury: *A Child's Vocabulary*; Educ. Rev., VII., pp. 287-290.

[3] Wolff: *A Boy's Dictionary*; Child Study Monthly, III., 1897, pp. 141-150.

Psychology indicates the following lines of treatment. (1) Create a desire for the use of language by placing the pupil in situations which require its use—orally at first, afterwards in writing. (2) Create a healthy dissatisfaction with his previous efforts by making him realise that he is neither adequately pleasing himself, nor producing the desired effect upon others. (3) Lead the pupil to solve his difficulties by using his own resources, or other aids to which the teacher may direct his attention.

From the above remarks it may be inferred that the author has little sympathy with the teaching of grammar in the elementary school. Grammar does not teach correct speech; it only enables one to judge of its correctness after utterance, *i.e.* it makes self-criticism more effective. The grammatical instruction should be limited to the teaching of facts that have a direct bearing upon the use of language as a means of expressing and interpreting thought. It should be incidental to the practical study of language and should evolve from it. At most it ought to be limited to the last year of school-life when it perhaps could be used as a foundation for further linguistic study.

READING.

From a sociological point of view, reading (with writing) is important because it enables the race to transmit its knowledge in an easily accessible form.

From a psychological point of view, the ultimate problem of reading is that of obtaining a meaning from an arrangement of certain highly artificial symbols. The psychological processes involved in the act are both numerous and varied. These consist of—(*a*) A retinal impression of the printed symbols which is followed by the percept of the word. (*b*) The percept is followed by various forms of imagery among which may be the auditory image of the word, the visual image of the word, or the articulatory image of the word. (*c*) Depending upon some form of imagery we get the actual articulation of the word, either silently or audibly, and from this (*d*) We arrive at the actual meaning. The most usual series in reading seems to be—retinal impression, percept, auditory image, actual articulation and meaning. Visual imagery seems to play a very minor part.

The investigations of psychologists[1] have been mainly directed to the elucidation of the following problems:

The Work of the Eyes in Reading. Contrary to general opinion, the eyes in reading do not move in smooth sweeps across the page but in a series of jerks. These jerks are separated by pauses or rest periods, but the sweep from one line to the next is usually accomplished in one movement. The quicker the reading the fewer the pauses and the shorter their duration. The number of pauses depends, therefore, on the length of the line and the familiarity of the subject matter. In reading unfamiliar material such as an imperfectly known foreign language, the movements diminish in length and the duration of the rests increases. The average time occupied by a forward movement is given by Dodge and by Dearborn as 0·023 second;

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[1] The material for the rest of this section has been culled in the main from:

(1) Huey: *Psychology and Pedagogy of Reading.*

(2) Dodge: *An Experimental Study of Visual Fixation*; Psy. Rev. Mon. Suppl., VIII., 4, 1907.

(3) Quantz: *Problems in the Psychology of Reading*; Psy. Rev. Mon. Suppl., II., 1, 1897.

(4) Woodworth: *Vision and Localisation during Eye-Movements*; Psy. Bull., III., 2, 1906.

(5) Dearborn: *The Psychology of Reading*; Columbia Univ. contrib. to Phil. and Psy., XIV., 1.

(6) Erdmann and Dodge: *Die Psychologischen Grundlagen der Beizichungen zwischen Sprechen und Denken*; Archiv f. Systemat. Phil., III., 1897.

(7) Cattell: *Time and Space in Vision*; Psy. Rev., VII, 325-342, 1900.

(8) Goldscheider and Müller: *Zur Phys. und Path. des Lesens*; Zeit. f. Klin. Med., XXIII., p. 131.

(9) Pillsbury: *A study in Apperception*; Amer. Jour. Psy., VIII., 3, 1897.

(10) Smith: *The Psychology of Adult Reading*; Brit. Ass. Report, 1912.

(11) Zeitler: *Tachistoskopische Versuche über das Lesen*; Wundt's Phil. Stud., XVI., 3, 380-463.

(12) Beer: *Die Abhängigkeit der Lesenzeit von psychol. und sprachlichen Factoren*; Zeit. f. Psy., 56, 1910.

(13) Dockeray: *The Span of Vision in Reading, and the Legibility of Letters*; Jour. of Ed. Psy., I., 3, 1910.

the average time for a rest with fast readers is ·185 second, although the variation is so great that a pause may be of any length. From three to seven pauses are made in a line of this print. The pauses are within the line, the last being further from the end than the first is from the beginning, and the average distance between the extremes is only 78 to 82 per cent. of the width of the line. The first fixation is the longest, and Dearborn suggests that this extra time is used in giving a general glance along the line. The same writer also states that persons fall into a fixed motor habit of making a certain number of pauses per line and into a steady rate of reading, but that the latter can be consciously speeded up. There is less fatigue caused by wide angle sweeps, hence the tendency is for children to place the eyes too near the page, thus causing myopia.

Although the speed of a sweep is sufficiently great to cause the black ink and white paper to form a grey blur, no such effect is perceived by the reader. Woodworth has shown that the eye is not wholly anaesthetic during movement as was formerly supposed to be the case: still we practically read only at the pauses and that by "eye-fuls." It is probable that we ignore the effect of the grey blur just as we ignore many of the faint sensations of ordinary life.

Eye-movements were first recorded by Javal in 1879. Erdmann and Dodge studied them more carefully in 1898 by using the mirror method of direct observations. They found that the eye was usually focussed upon the middle part of the words. Later Dodge actually succeeded in photographing the eye-movement. Huey studied them by attaching a plaster-of-paris cup to the cornea and recording the movements by a bristle pointer. He found rather fewer pauses than Dodge. Quite recently Dodge has found that the eye is not fixed steadily during a so-called pause, but quivers or vibrates incessantly.

Children need to be taught to move the eyes from one line to the next and therefore one line sentences for the first Readers are pedagogically faulty. An indentation of an "m" at the beginning of alternate lines would probably be helpful.

The Area of Fixation. The amount seen during a reading pause is very small. The space which represents the area of distinct vision is not greater than seven letters if these do not form words. Yet the amount of sensible material which can be read in a Cattell Fall Apparatus—a variety of tachistoscope—amounts to sixteen or twenty letters. Dockeray found that the span of distant vision for letters in 10 point type at a distance of 35 cm. from the eyes was from 20 mm. to 22 mm. on either side of the fixation point. Under favourable circumstances as much as half a line could be read at a glance of such a brief duration that eye-movements were precluded. It may therefore be inferred that the majority of the letters are filled in by pre-perception. We read more than we see clearly but usually less than is possible under concentrated attention.

More is read to the right of the fixation point than to the left, and the amount read depends on the sequence of letters or words and on the familiarity of the material.

The Speed of Reading. The rate of reading is a very variable quantity ; the fast reader may read four times as quickly as the slow one. The normal rate of reading for a person is reduced by lip movements if these are not habitual. It is increased by great familiarity with the subject matter. A foreign language is read at a much slower rate, although the subject may think he is reading it as quickly as he reads his native tongue. Rapid readers not only do their work in less time but also do superior work. Calkins, Quantz and others have found that the quick readers remember most and for a longer time. Romanes, however, found that among the subjects he tested, several slow readers were highly distinguished scholars.

Lip-movement is a serious hindrance to the speed of reading ; other influences at work are the habitual quickness of perception, the training and practice the subject has had, and the degrees of concentration and scholarship he exhibits. Prandtl has recently shown that serious texts are read more slowly than cheerful ones, and that even the suggestion that the text is bright or sad will alter the rate of reading. Beer has shown that the rate is decreased as the proportion of monosyllables increases.

Since rapid reading is beneficial, at least where reading for ideas is concerned, as opposed to reading for the musical rhythm as in poetry, children ought to be helped consciously to increase their normal rates of reading. For the reading of novels, the author has increased his rate from 40 to 100 pages per hour during the past six years.

Inner Speech and the Act of Perception. By inner speech is meant the silent or internal pronunciation of words which accompanies silent reading; a movement is felt in the throat and it sometimes becomes so marked as to spread over into lip-movement. In quick silent reading every word is not pronounced in full; only the beginnings are attempted and these are sufficient to give the meaning. Young children invariably are lip-movers. Lip-moving is probably a reflex action arising out of the predominant rôle played by oral speech in the early history of the race. It is a manifestation of the psycho-physical law of dynamo-genesis by means of which every mental state tends to express itself in muscular movement. Adults overcome the habit by practice. Quantz found that of adults 10·4 per cent. were pronounced lip-movers, 29·5 per cent. were medium lip-movers, and 60·1 per cent. had no movement whatever. Silent reading with inner speech is much quicker than reading aloud, and some persons read so quickly that inner speech is abolished; they are "eye-readers." Inner speech does not depend on the breath, it takes place during inhalation and exhalation. It always lags behind the eye also. The distance between the two is variable, being greater at the beginning of a new line. If in silent reading, or better still in reading aloud, a card is placed over the printed page, the subject is afterwards able to read on for a considerable number of words. Quantz found that when the reader is pronouncing the word at the beginning of a line, the eye is on an average 7·4 words in advance of the voice; in the middle 5·1 words; at the end 3·8; the average is 5·4. The eye-voice separation is less in unfamiliar passages. All authorities are agreed that inner speech has an important bearing upon the perception and interpretation of the printed matter. Whether the consciousness of meaning accompanies the visual recognition, or is delayed until after the inner utterance, is still an unsettled problem. It probably begins between the eye and the voice and is completed by inner speech.

Other elements in the perception of printed words are as follows:

The upper part of a line of print is more important than the lower; we are able to read print from which the lower half has been removed, but it is almost impossible to do so if the upper half is deleted.

It is not necessary to see clearly all the constituent parts of a word before it can be read. Goldscheider and Müller, Zeitler, and Wiegand have shown that only ghostly outlines of familiar words are seen; these are filled out and the words are recognised. Some letters play a more prominent part than others and to these the term "dominant" has been applied. The letters which project above and below the line tend to be dominant. The first part of a word, as Huey showed, is also more important than the second. The outline form of a word is a very inconstant quantity as may be seen by placing the same word in written, typewritten and various kinds of printed characters side by side. So important is the outline form in word perception, that print can be read at a distance which makes the separate letters indistinguishable.

The unit of perception in reading is the word, phrase, or sentence as suits our purpose best. Cattell has shown that easy words of four letters can be perceived as quickly and as easily as each of the component letters, and that some letters are more legible than others. Dockeray found that broad letters are much less confusing than tall narrow ones. In one of Huey's experiments—

50 letters were read in an average of			15·7	seconds.
50 four-letter	words	were	17·3	,,
50 eight-	,,	,,	19·6	,,
50 twelve-	,,	,,	28·5	,,
50 sixteen-	,,	,,	54·1	,,

With more familiar material, phrases and even short sentences may be perceived at a glance not exceeding one-hundredth of a second in length, but it must be admitted that the artificial conditions of the experiment may introduce factors which are not normally present in ordinary reading.

"Huey concludes, as did Goldscheider and Müller, that sometimes the total form is sufficient for recognition, at other times a dominant complex is the first factor. But in either case there is only one total act of recognition inside which the dominant parts or the total form occupy a greater prominence in consciousness. The tendency is towards the recognition in larger and larger units, with occasional descents to single word recognition, or even letter recognition." [1]

The Pedagogy of Reading. In addition to the principles of teaching formulated in previous parts of the chapter, a few modifications of method suggested by Psychology may now be mentioned. The first of these is that an eclectic method of teaching children to read, with an emphasis on the "look and say" method, is probably the best. The second is that word drill should be kept out of books and that nothing artificial such as diacritical marks should be introduced. Thirdly, one line sentences and short "snippity" stories are especially bad, since they give no opportunity for holding thought, as it were, in solution. The child must learn to hold bigger and bigger elements in the mind, hence a book with a long story is valuable even for the beginning stages. Fourthly, words are not difficult simply because of their length; the meanings which are attached to them are the stumbling-blocks in thought getting. Many short words like is, was, the, when, it, who, if, and, but, on, in, out, etc., are infinitely more difficult than many ten or twelve letter words. They gather meaning from their context, hence words, if possible, should never be given apart from context. Lastly, greater attention should be paid to the hygiene of reading; many Readers leave much to be desired with respect to legibility.

HANDWRITING.

Writing, in the evolution of language, developed contemporaneously with reading. Pictures, or ideographs, appear to have been the earliest form of writing and from these, alphabets have gradually evolved. Handwriting was fairly late in its development and is rapidly giving way to machine-writing. However, we are yet a long way from the time when handwriting will be no more, and the question of the teaching of handwriting still remains one of the thorniest of pedagogical problems.

Handwriting may be studied from the standpoint of (1) Relative ease of execution. Under this head the movements of the hand and arm concerned with handwriting should be studied from the standpoint of physiology and hygiene. (2) The legibility of the finished product. Our judgments of "goodness" or the quality of handwriting largely depend upon legibility. (3) The speed with which the writing can be done. This obviously depends, in part, upon the ease of movement. (4) The aesthetic appearance of the finished product.

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[1] Smith: *op. cit.*, ; section 4.

For teachers, the main problem is, "how to secure a working combination of speed and legibility," yet more attention is devoted to aesthetic qualities than to any other.

Movements concerned with Handwriting. Judd[1] investigated the writing movements experimentally and concluded: "(1) In ordinary writing the fine formative movements are executed by the fingers. (2) The movement which carries the fingers forward is executed by the hand or arm. (3) The pauses between the groups of letters are utilised for longer forward arm movements which bring the hand back into an easy working position. (4) A comparison of the different types of co-ordination obtained from the experiment shows that each individual has his own peculiar combination of arm and hand and finger movements, and that forms of co-ordination are as numerous and varied as are the individuals who write. (5) The hand usually requires a few strokes at first to adjust itself; the necessary adjustment sometimes being brought about by a greater emphasis on finger movement and sometimes by a more pronounced hand movement. (6) Any change in the condition under which the subject writes will modify the character of co-ordination, *i.e.* changing from a hard to a soft pencil, from a vertical position of the paper to an oblique, will produce variations in the character of the muscular co-ordination, even when the product of the movement (the written letter) does not seem to be changed."

McAllister[2] found that most of the movements used in writing follow the radii of the first and third quadrants. Movements in the third quadrant are quickest, those in the second and fourth are both slower and less numerous. These results indicate that a sloping handwriting is more natural and economical than an upright one. But a slope above 15° away from the vertical, although adding to the speed, seriously reduces its legibility.

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[1] Judd: *Genetic Psychology for Teachers*; Chap. VI. Summarised by Thompson: *Psychology and Pedagogy of Writing*; p. 73.

[2] McAllister: *Researches on Movements used in Writing.* Studies from the Yale Psychological Lab., VIII., p. 63.

Woodworth[1] carried out a series of experiments with adults to find out which was the easiest type of writing movement. He found that a forearm movement with the elbow resting on the desk was to be preferred either to the whole arm movement or to the movements of the fingers. This method of writing is somewhat more difficult to learn, but in the long run it produces the best results both in speed and in legibility.

Women are generally found to write more quickly than men and to distribute the pressures differently.[2] With the masculine type of writing, the pressures are rhythmically distributed over the word and exhibit a maximum at a definite point in each word, generally at the beginning or end. The average pressure also increases with the speed. The feminine type of handwriting, which is not confined to women, decreases its pressure with speed and does not exhibit the same rhythmical effect.

These variations in pressures and in rapidity of movement are the chief causes of the sex-differences which handwriting exhibits. Downey[3] found that it was possible to judge of sex correctly in perhaps 80 per cent. of the cases. Originality is a mark of the man's handwriting; conventionality that of the woman's.

Legibility of Handwriting. Goodness or merit in handwriting is dependent upon legibility and aesthetic values; legibility depends upon spacing of lines, spacing of words, and on the form and regularity of the individual letters. Attention to spacing, especially the spacing of words, increases the legibility of handwriting far more than attention to the form or regularity of letters. In an experiment, carried out by the writer in 1911, the handwriting of a class improved, in the space of a month, by 30 per cent. (measured by Thorndike's Graphometer *infra*), through the simple expedient of insisting on a space equal to the width of a letter "m" being left between each of the words. The spacing between the lines should be sufficiently great to prevent the overlapping of loops and tails. Regularity is a more important factor in legibility than form, although the latter is more often emphasised by the teacher than is the former.

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[1] Woodworth: *Accuracy of Voluntary Movement*; Psy. Rev. Mon. Suppl., III., 2, 1899.

[2] Freeman: *Preliminary Experiments on Writing reactions*; Psy. Rev., VII., pp. 301-34.

[3] Downey: *Judgment of sex in handwriting*; Psy. Rev., XVII., 1910.

The following rules of the Civil Service Commissioners are excellent for promoting legibility. The modifications in parenthesis are suggested improvements.

> "1. Each letter and each figure should be clearly and completely formed, so as to avoid the possibility of one letter or figure being mistaken for another; and the slope from the vertical should be even and not exceed thirty degrees.
>
> "2. The characters should be of moderate and even size. The projection of capitals and long letters above or below the line should not be more than one and a half times the length of the short letters. Flourishes and superfluous strokes should be avoided.
>
> "3. There should be moderate and even spaces (at least $\frac{1}{16}$ inch, but not exceeding $\frac{3}{16}$ inch) between the letters in a word, and also between the words (at least $\frac{3}{16}$ inch, but not exceeding $\frac{5}{16}$ inch) in a sentence. The letters in a word should be united (?) by strokes; the words in a sentence should be unconnected by strokes.
>
> "4. The writing should be in straight lines, running parallel with the top of the page. The intervals between the lines (at least $\frac{1}{4}$ inch) should be even and sufficient to prevent the intersection of loops and tails."

Thorndike[1] has recently constructed a "graphometer" or scale by means of which merit (chiefly legibility) in handwriting may be judged. The scale consists of samples of handwriting graded from zero (no merit) to eighteen (the highest merit). The handwriting to be judged is compared with the scale and given a number accordingly. To understand how the scale is made, a knowledge of statistics is essential; the technical nature of the problem precludes discussion in this elementary work, but students wishing for further information may obtain it from the reference below.

Aesthetic Values of Handwriting. During the past two years an interesting experiment has been carried out in the Fielden School.[1] The aim of the experiment was to improve the handwriting of the scholars. Running script was prohibited and the writing of disconnected letters was substituted. The model, which was not unlike a "library" hand, was based upon the lettering found in mediaeval manuscripts, *i.e.* the handwriting was to be improved by directing the attention to aesthetic forms. The improvement in legibility of the writing has exceeded the wildest hopes of the experimenters, but the average speed has seriously decreased. So slow is this "semi-printing," that scholars in the upper classes tend to revert to the "running hand" when hurried and pressed for time. The particular forms of letters adopted are difficult to join together, hence it would seem that the experiment will have to be abandoned, in spite of its extreme value in promoting legibility, because the factor of speed makes it so wasteful of time.

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[1] Thorndike: *Handwriting*; Teachers' Coll. Record, XI., 2, 1910. The Scale is also reprinted in Thompson: *Psychology and Pedagogy of Writing.*

Speed of Handwriting. The speediest form of handwriting is that which employs the fore-arm movement in its execution, but the quickest handwriting is only as speedy as moderately quick typewriting. Burt[2] found that speed of writing correlates fairly highly with General Intelligence.

Teaching of Handwriting. The modifications of teaching method which Psychology suggests are—(1) devote more attention to spacing, especially to the spaces between words, and less attention to the forms of letters than is customary at the present time ; (2) use less finger movement and depend more upon the fore-arm, pivoted at the elbow, for both fundamental and accessory movements ; (3) allow greater individual freedom of style ; the moulding of children's handwriting to one fixed style seems a pure waste of time, since individual differences will appear as soon as the discipline of school is removed ; (4) handwriting, like reading, should only be a "subject" for the lower classes ; in the higher classes it should be regarded simply as a tool for use in more important branches of the curriculum.

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[1] Connected with the Education Department of the University of Manchester.

[2] Burt : *Experimental Tests of Higher Mental Processes and their Relation to General Intelligence* ; Jour. Exper. Ped., I., p. 93.

SPELLING.

Spelling is of practical importance in language only so far as it is connected with the writing of it. Before language was "fixed" by writing and bound down firmly by printing, spelling could not possibly play any part in it. Our irrational spelling causes a large proportion of school time to be devoted to the teaching of this branch of the curriculum and, until recently, no criticisms were levelled against the possible waste of time or the teaching methods in vogue. Experimental investigations during the past twenty years, while not solving the problem, have led us to a new appreciation of the difficulties surrounding it.

The Psychology of Spelling. The problem of the psychology of spelling is to discover the steps in the mental process which will enable us to pass from the meaning of the word to its actual articulation in letter sequence or its writing. This to a large extent is the reverse process of reading, where the passage is from the written or printed form to the meaning it conveys. When the habit of spelling has been acquired the process seems simply to be: (1) a recall by memory of the word which fits a felt meaning; (2) consent is now given to the writing of it; and (3) the writing takes place automatically. But there are many steps, which have never yielded to introspective analysis, between (2) and (3). These steps depend upon mental images which help the recall, in conventional order, of the symbols composing the word, and these vary in different individuals. In some, visual images of the individual letters play an important part; in others, auditory images of the sounds composing the word, or motor images of the speech-movements involved in pronouncing the word, or motor images of the hand-movements involved in writing the letters, may be of greater significance. It is very probable that no one depends absolutely upon one form of image, but that all forms may help towards a correct spelling of the word. The importance of visual imagery has been exaggerated, for it has been shown by many experimenters that visual imagery is seldom powerful enough to be functional. The person who spells by visual imagery will certainly never need to write a word to see if it is spelled correctly.

Spelling therefore may be said to be a sensori-motor habit acquired by repeated motor reactions to certain sensory stimuli. The sensory stimulus is usually the written or printed word as in reading, but it may be the sound of the word in letter sequence. From this we get the percept. Arising out of the percept of the word and out of the actual writing of it, we get the development of the various images which ultimately enable us to spell the word correctly by the use of some form of motor-activity. The movement-images for the separate letters are learned in the first instruction and these later combine to form movement-images of syllables and words.

The earlier psychology of spelling was certainly false. It assumed that spelling was a method of memory supported by certain rules and this led to a false pedagogy of the subject in which lists of isolated words from a spelling book played a conspicuous part. Memory certainly has little to do with it. Business men who dictate all their letters to stenographers do not forget how to spell. The ability to perceive minute differences, which is largely innate but may be trained, is much the most important factor.

Experimental Studies of Spelling. The earliest experimental investigations of the problem were carried out in Germany[1] by Lay, Schiller, Lobsien, Itschner and others. Lay endeavoured to evaluate the shares that hearing, sight, speech and writing have in the process of learning to spell. He devised a series of experiments in dictation, reading, oral spelling and transcription. Nonsense words were used in order to provide material of uniform difficulty, and various groups of scholars were tested. The number of mistakes per scholar worked out as follows :

Hearing without vocalising	3·04	per scholar.
Hearing without speaking in an undertone	2·69	,, ,,
Hearing without speaking aloud	2·25	,, ,,
Seeing without vocalising	1·22	,, ,,
Seeing with speaking in an undertone	1·02	,, ,,
Seeing with speaking aloud	0·95	,, ,,
Spelling aloud	1·02	,, ,,
Transcription	0·54	,, ,,

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[1] See (1) Meumann : *Vorlesungen zur Einführung in die experimentelle Pädagogik* ; (2) Rusk : *Introduction to Experimental Education* ; (3) Burnham ; *The Hygiene and Psychology of Spelling* ; Ped. Sem., XIII., p. 474 ff., 1906.

The eye on the average plays a much more important part than the ear. Transcriptions, which involved writing movements and the sight of the word, gave the best results. Lay was inclined to think that motor-imagery, both vocal and graphic, played a predominant part in spelling, but Fuchs and Haggenmüller showed, by using 'imaginary' writing, that the inference was not valid.

More recently, American investigators have carried out a large number of researches into the pedagogy of spelling. Rice [1] was the originator of the particular type of investigations. He tested the abilities of 33,000 children in grades V., VI., VII. and VIII. These children came from all classes of society, had been taught by various methods, and had received instruction for differing daily periods—15, 20 and 40 minutes. In addition, Rice interviewed two hundred teachers in regard to the methods they used and the results they obtained. The test words were given in three ways: (1) standing alone; (2) in sentences; and (3) in composition written on a story basis.

The results, which he obtained, were somewhat startling. They were briefly as follows:

1. The ability to spell in a given grade was not determined by age. The results do not favour the older pupils in a grade. (Older children are probably dullards.)
2. The best spellers as a rule are to be found among the brightest pupils.
3. The influence of nationality is nil. If anything, the results slightly favour the foreign element.
4. The influence of methods of teaching is nil.
5. There was no difference in spelling ability exhibited as a result of much or little home reading by pupils.
6. All the time devoted to teaching of spelling beyond a certain maximum (not exceeding 15 mins. a day) is wasted.

As a conclusion he states: "The facts presented, in my opinion, admit of only one conclusion, namely, that results are not determined by methods employed but by the ability of those who use them. The first place must be given to the personal equation of the teacher, while methods and devices play a very subordinate part. In learning to spell maturity must be considered one of the leading factors."

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[1] Rice: *The Futility of the spelling Grind*; Forum, March and April, 1897.

These unexpected results of Rice led to a further investigation by Cornman,[1] who gave a number of spelling tests in various schools and also got two schools to abandon the use of the spelling book and home lessons in the subject, and to omit the spelling period from the school programme for a period of three years in order to see what effect it had on the spelling of the scholars. Five kinds of tests were employed: (1) Words spontaneously selected by the pupils during a period of fifteen minutes; (2) dictated words; (3) dictated sentences containing selected words; (4) Superintendent's terminal examinations in spelling; (5) daily composition work.

The results which Cornman obtained showed that: (1) The pupils neither gained nor lost appreciably by the omission of spelling from the programme; (2) The amount of time devoted to specific spelling drill bears no discoverable relation to the results attained; (3) The degree of mental development is the most important factor in accuracy in spelling. The next most important is the personal efficiency of the teacher.

His conclusion is that "It is therefore advisable in view of the economy of time to rely upon incidental teaching of spelling to produce a sufficiently high average result."

The above results and conclusions have been severely criticised by Wallin.[2] After criticising Cornman's technique and logic, he states: "Pursued to their logical conclusion Dr. Cornman's results would convert systematic instruction and organised curricula into pedagogical monstrosities. If specific instruction or drill in spelling is valueless, why are they not a sheer waste in other branches as well? Accordingly why not do away with specific instruction or drill in the various subjects, and also the articulated curricula, which obtain in the schools at present? Leave all acquisition to merely incidental acquirement. The school would thus seem to offer but slight advantage over the home, street, shop, or field, except that it might afford a richer wealth of material for such incidental acquisition. Cornman foresaw the logical inevitableness of this conclusion and hastened to say that only the modes of expression arising inevitably and naturally should be left to incidental instruction." Wallin does not think that Cornman has made out a case for no drill, but simply a case against "Slip-shod, happy-go-lucky drill." Drill and formal work are as necessary as ever.

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[1] Cornman: *Spelling in the Elementary School.*

[2] Wallin: *Has the Drill become Obsolescent?* Jour. of Ed. Psy., I., 4, pp. 200-214.

An English contribution to the subject of spelling[1] emphasises the necessity of dividing mistakes of spelling into those made through ignorance and those made accidentally. The latter should not be judged too harshly.

Douse studied the spelling mistakes of about 1,000 Cambridge students made under the time pressure of an examination. Generally speaking the cause of the perturbations was found to be a momentary withdrawal of attention from the point at which the pen had arrived in the process of writing and its transference to some neighbouring point on the line of ideas which the mind had evolved or was striving to evolve. He gave the following somewhat pedantic classification of mistakes :

(1) Prolēpsis or Assimilation from ahead, *e.g.* s*k*e*k*el for s*h*e*k*el, s*p*oo*p*ed for s*t*oo*p*ed.
(2) Metapēdēsis or overleaping, *e.g.* prece*d* for preced*ed*, po*ss*ive for posse*ss*ive.
(3) Metallagē or cross-compensations, *e.g.* si*l*i*b*ants for si*b*i*l*ants, pa*d*o*g*a for pa*g*o*d*a.
(4) Opisthomimēsis or assimilation from the rear, *e.g.* b*i*sh*i*p for b*i*sh*o*p, sy*n*o*n*y*n*s for sy*n*o*n*y*m*s, h*ouse*h*oul*d for h*ou*sehold.
(5) Contamination, *e.g.* T*ue*tonic for T*eu*tonic, after the word T*ue*sday had been written.

Similar mistakes are made in speaking but are not met with so frequently ; they also occur in well-printed reading matter.

Douse concludes that such mistakes as the above should not be scored heavily unless the candidates have had instructions, and have been allowed time to read over their answers. (The same thing would apply to scholars in the upper classes of elementary schools.)

The Pedagogy of Spelling. In teaching scholars to spell, only the words in frequent use and likely to be used by them should be taught. Time should be economised as much as possible and the larger part of the instruction should be given in connection with reading and writing. A little carefully planned drill on two or three new words should be given each day. This should not exceed fifteen minutes.

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[1] Douse : *Psychology of Mis-spellings and related Mistakes* ; Mind, XXV., p. 85 ff., 1900.

The psychology of association leads one to deprecate any interference with associations already existing in the mind of the pupil. Reformed spelling and phonetic spelling lead to such interference and bad spelling is the result, hence the teacher will have to decide whether he will upset the spelling of this generation in order to confer a problematical benefit on the coming generation. For the same reason, he should aim at avoidance of error rather than correction of error; correct forms must ever be emphasised and the blue pencil used sparingly.

The instruction in spelling should have regard for individual differences of the reproductive imagination. All types of teaching methods should be practised, but for the majority of scholars, the best methods are those of writing, especially copying.

Further investigations into specific minor problems connected with teaching will have to be made before the pedagogy of spelling can be greatly improved. That of Pearson [1] which conclusively proved that it is better to teach homonyms together in pairs—piece, peace; colonel, kernel; peer, pier; etc.—rather than singly and separate, is an excellent example of this type.

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[1] Pearson: *The Scientific Study of the Teaching of Spelling*; Jour. of Ed. Psy., II., 5, 241-253.

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